Am. B.

Proceedings

3040.

(342)

INDEX

TO THE

EXECUTIVE DOCUMENTS

OF THE

HOUSE OF REPRESENTATIVES

FOR THE

FIRST SESSION OF THE FORTY-SEVENTH CONGRESS,

1881-'82.

IN 26 VOLUMES.

VOLUME 4.—Engineers, No. 1, part 2, volume 2, part 2.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1882.

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REGIA
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47TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE FIRST SESSION OF THE FORTY-SEVENTH CONGRESS.

IN FOUR VOLUMES.

VOLUME II.

PART 2.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1882.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX J.

IMPROVEMENT OF THE RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA, GEORGIA, AND THE ATLANTIC COAST OF FLORIDA.

REPORT OF LIEUTENANT-COLONEL Q. A. GILLMORE, CORPS OF ENGINEERS, BVT. MAJ. GEN., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
New York, July 25, 1881.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieutenant Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

J 1.

IMPROVEMENT OF THE HARBOR OF CHARLESTON, SOUTH CAROLINA.

During the fiscal year ending June 30, 1881, operations were carried on in prosecution of the plan of improvement, by means of two jetties submitted March 9, 1878, as shown in Appendix H, of the Annual Report of the Chief of Engineers for that year.

It is designed to establish and maintain a low-water channel at least 21 feet deep across the bar, upon which the greatest available depth has heretofore been only about 11½ feet.

Previous to the spring of 1878, there had been expended in the improvement of the ship channels in Charleston Harbor, from 1871 to 1878, the sum of $93,700 in taking up the wrecks of fourteen iron-clad and wooden vessels sunk during the civil war, and in removing a portion of the Bowman jetty projecting into Beach Channel.

BRIEF RECAPITULATION OF OPERATIONS PREVIOUS TO JUNE 30, 1880.

North jetty.—The work of laying the apron of this jetty was begun in 1878. On June 30, 1880, the seaward end of the apron was at a distance of 9,601 feet from the starting point on the shore of Sullivan's Island,

measured along the axis of the work, but the length actually covered by the mattresses was 7,654 feet, a gap having been temporarily left on Drunken Dick Shoal, for reasons given in my last report contained in Appendix I 1, of the Annual Report of the Chief of Engineers for 1879.

The widths of the apron varied from 43 to 113 feet, and the thicknesses, including riprap stone, from $2\frac{3}{4}$ to 6 feet. For a length of 1,648 feet a hearting composed of a second log and brush mattress was put in to gain height and lessen the cost.

South jetty.—The laying of the foundation course for this work was commenced in April, 1880. By June 30, 1880, it had reached a length of nearly 2,550 feet. This apron consisted of a log and brush mattress $1\frac{1}{2}$ feet thick, overlaid with riprap stone to a thickness in the work of about $1\frac{1}{4}$ feet, giving a total average height of about $2\frac{3}{4}$ feet. The widths varied from 40 to 42 feet.

OPERATIONS DURING THE FICAL YEAR ENDING JUNE 30, 1881.

Work on both jetties was continued during the fiscal year just closed, under four different contracts, three of which were made since June 30, 1880.

Work under the contract made September 6, 1879, with Bangs & Dolbey, referred to in my last annual report, was completed during the year.

On August 7, 1880, a contract for furnishing and putting in the work, 20,000 cubic yards of riprap stone, was concluded with Mr. F. P. Murphy, of Washington, D. C., who was the lowest bidder, under a call for proposals dated June 28, 1880. He was to commence work by September 1, 1880, and make progress at the rate of 2,000 cubic yards per month. He did not begin before November, and his progress was so slow that the contract was annulled under authority granted April 11, 1881.

The sum of $170,000 having been appropriated by act of Congress approved June 14, 1880, proposals were invited August 19, 1880, to continue work on the two jetties to the extent of that appropriation.

The work for which bids were invited was to be constructed in a course composed of a mattress 18 inches thick, overlaid with riprap stone 12 inches deep. Additional stone to the amount of 10,000 cubic yards was also to be furnished and placed in the work.

The following description of the mattress is taken from the specifications dated August 19, 1880:

Either of the three designs for mattresses described below will be acceptable to the United States.

FIRST DESIGN FOR MATTRESSES.

This mattress is simply a raft or platform of round logs, not less than 12 inches in average diameter (nor less than 9 inches at the small end), placed close together, side by side, at right angles to the line of the jetty, and firmly held there by transverse binders spiked or bolted to them.

The binders will be smaller logs flattened on the lower side, and not less than 6 inches in depth at the small end, and the average depth through binder and log at the points of fastening will not be less than 18 inches. The binders will be placed not more than 8 feet apart, and those on the outside will be close to the ends of the logs.

The spaces between the binders, except the two outside spaces, one on each side over the ends of the logs, will be filled with short logs, saw-mill slabs, or other suitable material. This filling will be firmly held in place by pole-binders, or by some other suitable method.

SECOND DESIGN FOR MATTRESSES.

This mattress will consist of the raft or platform secured by binders, as above described for the first design, the same to be overlaid with stout brush to an average depth of 6 inches estimated in the finished jetty. The contractor will be allowed to make the layer of brush only 4 or 5 inches in average thickness, provided the sizes of the logs are correspondingly increased, so as to produce a mattress not less than 18 inches thick in the finished work. The brush is to be closely compacted and firmly and securely held in place, and will project in a thick mass 3 to 4 feet beyond the ends of the logs.

The logs used for the mattress may be loblolly, or other cheap variety of pine. They must be of gentle taper, as straight as can be procured, and those of as nearly the same size as possible will be selected to go together.

THIRD DESIGN FOR MATTRESSES.

This mattress will consist of a bottom grillage of poles, of an average diameter of at least 6 inches, and not less than 5 inches in diameter at the small end, placed in each course not more than 5 feet apart between centers, and the lower poles will be parallel to the line of the jetty. The spaces between the upper poles will be filled in with similar poles, or with saw-mill slabs, or with an equivalent of stout brush, at the option of the contractor. Upon this will be placed two layers of stout brush, each 6 inches thick in the finished jetty, to be followed by a top grillage constructed like the one placed at the bottom. The poles of each grillage will be securely lashed together at the points of crossing, and the upper and lower grillage will be firmly connected together by suitable lashings, in such manner as the engineer in charge shall approve.

The foundation mattress will be laid in sections of convenient length, and each section will be made of the full width of the apron, as fixed by the engineer in charge.

Gaps exceeding 6 inches in width between the edges of adjacent mattresses, will be filled with stone at the cost of the contractor.

The stone will be sound, dense, of compact form, and of suitably random sizes, varying in weight from 15 to 250 or 300 pounds. Twenty-eight hundred pounds will be required to the cubic yard. If inconvenient to weigh it the quantity will be determined by measurement, for which it will be piled upon vessels, lighters, or elsewhere.

The first and third of the three designs described are shown in cross-sections on the chart accompanying this report; the second design is that originally used on the north jetty, and is represented on sheet 2 appended to my annual report for 1879. It was optional with contractor to select either of the three designs.

The bids were opened September 14, 1880. Those offered for the mattress overlaid with stone were deemed too high, and new proposals were invited by circular letter. Mr. Nicholas A. Devereux was the lowest bidder and the work was awarded to him at $10.73 per linear foot of course 54 feet wide. Although he agreed to begin within 90 days, and to make progress at the rate of not less than 750 linear feet per month, no work had been laid at the close of the fiscal year.

The annulment of this contract will be recommended.

Of the bids for furnishing 10,000 cubic yards of stone, that made by Mr. O. J. Jennings, of Fulton, N. Y., at $2 per cubic yard, was the lowest, and the contract was awarded to him. He, and subsequently his bondsmen, refused to enter into any agreement unless all the work covered by the specifications was embraced in it, and it was not thought advisable to begin suit against them.

Under these circumstances it was determined to expend about $17,000 of the sum thus left unpledged in putting down additional apron work, composed of a mattress 18 inches thick, covered with riprap stone to a depth of 1 foot, reserving a balance of a few thousand dollars for other purposes. Mr. Moses Dolbey was the lowest bidder for this work, and a contract was made with him January 31, 1881, at $13.45, for an apron course 54 feet wide. Work under this contract was finished in April.

By act approved March 3, 1881, the sum of $175,000 was appropriated for continuing this improvement, and proposals were invited April 16 for extending the foundation of both jetties and raising one or both to higher levels; the work to consist of mattresses overlaid with stone, and in stone put on work previously laid, or elsewhere, if required. Two designs for mattresses were described in the specifications, one of them being simply a raft of round logs 12 inches in diameter, while the other was essentially like the third design mentioned in the specifications of August 19, 1880.

A contract for this work was made June 11, 1881, with Mr. E. T. Bangs, the lowest bidder, at 70 cents per square yard for the log mattress in place, and $3.70 per cubic yard for riprap stone in place. Under a supplementary agreement the log mattress is to be overlaid with live hard-wood brush, at the rate of 17 cents per square yard of brush 6 inches thick in the finished work.

PROGRESS DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

North jetty.—The seaward extension of this work was continued in a direction determined by successive 400-feet chords of a circle of 1.6 statute miles radius, until December, 1880, at which time the aggregate length of apron actually laid was about 8,500 feet. At that date the gap 1,663 feet long still existed on Drunken Dick Shoal. From that time to June 30, 1881, the extension seaward has been upon a straight line bearing south, 58 degrees east, tangent to the circle. On June 30, 1881, the seaward end of the north jetty was 12,042 feet from the shore of Sullivan's Island, measured along the axis of the work, and the work for that distance was continuous.

The total length of apron laid during the year was 4,388 feet, inclusive of the Drunken Dick Gap, which was closed.

The widths of mats laid in extending the work outside of this shoal varied from 113 feet to 118 feet, the greater width being at the outer end of the work. The width used for closing the gap was 64 feet.

During the fiscal year just closed 24,675 cubic yards of stone were deposited upon the north jetty, including that supplied under the Murphy contract and by purchase in open market after that contract was annulled.

The total quantity of stone placed on this work, from the beginning to June 30, 1881, is 65,514.5 cubic yards.

South jetty.—The apron foundation of this jetty was continued on the straight course adopted in starting the work, the center line bearing south 87° east. During the fiscal year 4,363 linear feet of apron was added to the work. The seaward end was therefore 6,913 feet from the shore end on Morris Island. It has crossed the main channel, where the greatest depth found was 39 feet at mean low-water, about 5,870 feet from shore. The width of this channel between the 18-foot curves is about 1,400 feet. The eastern slope of the channel is much steeper than the western.

The widths of mats laid during the year ranged from 42 to 112 feet, and the aggregate thickness of mattress and stone is about $2\frac{3}{4}$ feet.

During the fiscal year just closed 11,114.3 cubic yards were placed on this jetty. The aggregate amount deposited from the beginning of operations to June 30, 1881, being 15,314 cubic yards. All this stone was supplied as a component part of the apron foundation.

The question relative to the transfer to the United States of the land on Morris Island upon which the shore end of the south jetty has been

located, is still in an unsettled condition, and may perhaps remain so indefinitely.

Dredging.—Toward the close of the fiscal year the United States dredge steamer Henry Burden was for some time employed in dredging on the bar in order to ascertain whether the portion of the north jetty already constructed would have any influence in maintaining such increased depths in the proposed line of channel as might be gained by dredging.

The top of the bar was found to be uncommonly hard. As the appliances for cutting up the sand to facilitate its entrance into the suction-pipe did not operate satisfactorily, the work was discontinued after a short time.

Besides the usual field work necessary for ascertaining the location and extent of work done by the contractors on the jetties, numerous soundings were taken on the sites of the jetties and the area between them. The results of the more recent observations of this class are shown on the general plan accompanying this report.

THE CONDITION OF THE WORK.

There is no evidence reported of any loss of stone from any portion of the works from the action of the waves, or that there has been any settlement, except that mentioned in the last annual report as having been discovered between Drunken Dick Shoal and Sullivan's Island. This settlement is inconsiderable, and is not to be attributed to underscour, or to the force of the waves. The work in that locality may overlie a bar of soft mud.

EFFECTS OF THE WORK.

From recent observations it appears that considerable deepening has occurred, at a place of some extent, about three-fourths of a mile southwest of the shore end of the north jetty, or one-half of a mile south of the westerly end of Beach Channel. Captain Greene thinks this is attributable to the influence of the north jetty and the gap on Drunken Dick Shoal, which was still unclosed at the time this deepening was observed, or possibly to the advance in a northeasterly direction of the large shoals of Fort Sumter. Apparently the rudimentary deep-water pocket, traceable on the Coast Survey chart of Charleston Harbor of 1870, at or near the head of the former north channel, is beginning to make out to the eastward. In the same area where this chart indicates a maximum low-water depth of 15 feet, there are now places found with depths ranging to 23 feet.

Some deepening has also been observed just south of the area referred to on the shoal between the heads of the north and the swash channels. It is not improbable that this increase of depth represents a gradual eastward advance of the deep-water area of the gorge between Sullivan's and Morris islands, induced by the partial protection and confinement of the ebb-current, by the apron of the north jetty. If so, the recent closing of the gap, and the raising of the work during the ensuing year, may be expected to further develop this movement.

Some shoaling has been noticed near and to the northward of the "Bell Buoy" shown on the chart. Captain Greene thinks this may have been produced by the deposit of material brought from the areas above mentioned where scour has taken place. Nearer to the north jetty, on the reach south of Drunken Dick Shoal, some little deepening has taken place. It is probable, however, that for some time not much gain in depth can be here expected from the action of scour, if the upper

layer of the bar should prove to be refractory to a considerable depth. It may be necessary to make some borings to decide whether the future channel should be established on this line, or somewhat to the southward of it.

Considerable scour has been observed at the northerly portion of the gap of Drunken Dick Shoal. According to Captain Post's report of July 1, 1880, 10 feet of water was then found, where previously but about 5 feet existed. These depths seem to have increased during the past fiscal year; some mattresses used in May last for closing the gap were sunk in water over 11 feet deep at low-tide. A strong current then passed through the gap, reaching a maximum velocity of about 4 miles per hour.

The shores of Sullivan's and Morris Islands are going away with considerable rapidity; so much so as to give occasion for apprehension with regard to the ultimate results, unless steps are taken to stop it.

Two short spur jetties on Sullivan's, and two and possibly three on Morris Island, would doubtless suffice to arrest the progress of this erosion. Their construction will be made the subject of a separate communication.

RECAPITULATION OF WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

North jetty.—There has been laid on the seaward extension a length of 2,725 feet of apron foundation, varying in width from 113 to 118 feet, and in height from $2\frac{3}{4}$ to 3 feet, composed of a mattress overlaid with riprap stone; and in Drunken Dick Gap a length of 1,663 feet of apron foundation similarly constructed, 64 feet wide, and $3\frac{3}{4}$ to 4 feet high.

In addition to the foregoing, 7,407 cubic yards of riprap stone were distributed over the apron south of Drunken Dick Shoal, raising the height in places to 13 and 14 feet.

South jetty.—There has been laid a length of 4,363 feet of apron foundation across the main channel, and east and west of it, varying in width from 42 to 112 feet, and in height from $2\frac{3}{4}$ to 3 feet, composed of a mattress overlaid with stone.

OPERATIONS CONTEMPLATED DURING THE FISCAL YEAR ENDING JUNE 30, 1882.

During the present fiscal year it is proposed to confine the work mainly to the north jetty, extending it seaward, and raising it to higher levels, by methods substantially the same as those hitherto followed, and to dredge along those portions of the proposed line of channel where it may appear to be most advantageous.

A few words may be offered concerning the amount of commerce interested in and to be benefited by the completion of the works of improvement now in progress at the harbor of Charleston.

It was hoped that some information would be obtained as to the amount and kind of traffic directed and brought to Charleston and our other Atlantic seaports from the Western and Northwestern States by the various transportation lines forming the Southern Railway and Steamship Association, but the efforts made for that purpose were not successful.

Interesting data were received from Hon. S. Y. Tupper, president of the Charleston Chamber of Commerce; from Hon. F. A. Walker, super-

intendent of the Census, and from other sources. Only some of the most important of the information supplied will be referred to.

Charleston is the largest city on the Atlantic coast south of Baltimore, its population according to the census of 1880 being 50,000.

The ample capacity of its almost land-locked harbor is well known. Cooper and Ashley rivers, bordering on either side the narrow peninsula on which the city is located, are broad and deep streams, with long reaches of bold shore, offering every possible advantage for the construction of wharves and piers.

Nearly all the shipping business of the place is done on the east or Cooper River side.

The wharves here are estimated to have accommodation for 200 vessels of average size, with a long, unoccupied water-front for future expansion. The wharf capacity on Ashley River is also great, although as yet unoccupied to a very large extent.

The warehouses on the Cooper River wharves have a capacity for 500,000 bales of cotton, besides the usual receipts of rice, naval stores, &c. Four steam cotton-presses are in operation, compressing from 5,000 to 6,000 bales per day; also, four rice-mills, pounding and cleaning daily about 250 tierces of rice of 600 pounds each.

Along the rivers are lumber and other mills, foundries, and machine shops, with ample room for enlargement.

The value of the real estate in the city is estimated at $25,000,000. It is asserted that values have advanced 10 per cent. within the past year. The sum invested for the accommodation of trade and commerce in the city, in the form of wharves, warehouses, mills, machine-shops, banks, railroads, &c., is estimated at $30,000,000.

Attention has been recently given to the manufacture of cotton goods, and preliminary steps have been taken to put up the necessary buildings and machinery.

The cotton crop of South Carolina has more than doubled since 1870. The total production of cotton in the United States in the year 1880 amounted to 5,730,968 bales. Of this crop, one-ninth was received at the port of Charleston. The value of this portion of the crop is estimated at about $34,000,000.

There has been a material increase in the receipts of cotton during the period named, as compared with previous years.

	Bales.
Receipt of cotton April 1, 1878, to April 1, 1879	506,077
Receipt of cotton April 1, 1879, to April 1, 1880	443,009
Receipt of cotton April 1, 1880, to April 1, 1881	630,014
Increase over last year	187,005

Next in value to cotton is the commerce in crude and manufactured phosphates, used for fertilizing purposes. There are twenty-two mining phosphate companies established at or near the rivers in the vicinity of the city, and six fertilizing mills either in the city or in its immediate neighborhood. The capital employed in this industry is estimated as $10,000,000. The aggregate business of the port in this article for the year ending April 1, 1881, amounted to about $4,000,000.

The total value of the business of the port for the year ending April 1, 1881, is estimated at $70,855,292, as shown by the following table of receipts and sales, furnished by Mr. S. Y. Tupper:

Cotton, upland, 613,290 bales	$30,664,500
Cotton, sea island, 17,014 bales	2,041,680
Rice, 44,487 tierces	1,557,045
Naval stores, 310,036 barrels	1,640,661
Phosphate, crude and manufactured	3,975,000

Lumber and timber, 16,133,000 feet	$533,406
Cotton goods, domestic	1,000,000
Fruits and vegetables	450,000
	41,862,292
Groceries and liquors	16,225,000
Grain and hay	983,000
Dry goods, shoes, and clothing	3,150,000
Drugs and medicines	450,000
Hardware	1,170,000
Paints and oils	365,000
Tobacco, cigars, &c	650,000
Beer	500,000
Other merchandise	2,000,000
Manufactures	3,500,000
	70,855,292

The maritime business of the port during the years 1878, 1879, and 1880 may be briefly shown as follows:

VESSELS AND TONNAGE ENTERED, BOTH FROM FOREIGN AND DOMESTIC PORTS.

1878: 772 vessels, aggregate tonnage	505,830
1879: 668 vessels, aggregate tonnage	460,689
1880: 670 vessels, aggregate tonnage	511,209

VESSELS AND TONNAGE CLEARED, BOTH FOR FOREIGN AND DOMESTIC PORTS.

1878: 609 vessels, aggregate tonnage	347,360
1879: 599 vessels, aggregate tonnage	348,546
1880: 587 vessels, aggregate tonnage	369,711

From the statement of arrivals and clearances of vessels at Charleston from January 1, 1875, to December 31, 1880, by the collector of the port, and appended to this report, it appears that the value of exports to foreign countries during 1880 was $24,939,259, exceeding largely that of any of the preceding years since 1875. The amount of duties collected in 1880 was $46,458.98 larger than during either of the next preceding two years.

Besides the river navigation north of the city afforded by Ashley and Cooper rivers, Charleston is connected by an inland water-route, via Wappoo Cut, with a large and valuable area of the coast district south of the city. Lately the value of freight passing through Wappoo Cut has amounted to nearly $3,000,000 annually.

Formerly the city was connected with the northern central portions of the State by the Santee Canal, extending from Santee River to the headwaters of the Cooper River; but this route is no longer available, having been neglected and allowed to fall into disuse and decay in consequence of the opening of competing lines of railroad.

Three railroad lines terminate at Charleston, viz, the South Carolina Railroad, the Northeastern Railroad, and the Savannah and Charleston Railroad.

The business of these railroads has greatly increased of late years. This might have been expected from the remarkable increase of population of the Southern Atlantic States in the ten years since 1870, and of South Carolina especially. The returns of the census of 1880 show an increase of 33.4 per cent. over 1870 in the aggregate population of North Carolina, South Carolina, Georgia, and Florida, while for South Carolina alone the increase was from 705,606 in 1870 to 995,622 in 1880, a gain of 41 per cent. The aggregate increase of the population of the whole United States and Territories for the same

period was from 38,558,371 to 50,152,866, or an increase of about 30.7 per cent.

The South Carolina Railroad connects Charleston with Columbia, the capital of the State. With its branches to Augusta and to Camden, its total length is 283 miles. By its connection at Columbia with the Charlotte, Columbia and Augusta Railroad, with the Wilmington, Columbia and Augusta Railroad, and the Greenville and Columbia Railroad (formerly Blue Ridge Railroad), it is well adapted to drain a large portion of the State. In fact it is considered to be the principal artery of trade of the city of Charleston with the interior. Together with the Northeastern Railroad, the South Carolina road draws a traffic from all the counties of the State southeast of a line that may be drawn from Augusta, Ga., to Cheraw, S. C.

The Charlotte, Columbia and Augusta Railroad, for a length of 110 miles from Charlotte, North Carolina, to Columbia, with the Chester-Lenoir narrow-gauge branch to Yorkville, drains the counties north of Columbia to near the boundary line between North and South Carolina. It is not likely that any noteworthy transit of goods takes place from the adjacent counties of North Carolina in the direction of Charleston, since the distance by rail from Charlotte to Wilmington, N. C., via the Carolina Central Railroad, is 188 miles, while it is 240 miles from Charlotte to Charleston via Columbia.

The Greenville and Columbia Railroad, 143 miles long, has a branch to Laurens, 31 miles long, and another 11½ miles long to Abbeville. It connects at Alston with the Spartanburg, Union and Columbia Railroad (68 miles), with its extension to Hendersonville by the Spartanburg-Ashville Railroad, 60 miles long; at Belton with the Blue Ridge branch 42 miles to Walhalla, S. C., and finally at Greenville with the Atlanta and Charlotte Air-line Railroad.

The distance by this air-line railroad from Greenville, S. C., to Atlanta, Ga., is 160 miles. The distance from Atlanta to Savannah by rail is 293 miles; from Greenville to Charleston, 273 miles. A point on the air-line railroad, about 70 miles from Greenville, is nearly equidistant, by rail, from Savannah and Charleston. That point is Lula Station, in Georgia, which also connects with Athens, Ga., by the Northeastern Railroad of Georgia. At Toccoa City, on the air-line road, 93 miles from Atlanta and 67 miles from Greenville, that road connects with the Elberton Air-line Railroad, Elberton being 50 miles from Toccoa City. It may be assumed from the foregoing that, other things being equal, the most northeasterly counties of Georgia will find it to their advantage to send their surplus produce to Charleston instead of to Savannah.

The Spartanburg, Union and Columbia Railroad, with its extension to Hendersonville, North Carolina, gives transportation facilities to the balance of the northern counties of South Carolina, and to some portions of Western North Carolina.

The Savannah and Charleston Railroad brings to Charleston the produce of the southern coast counties of the State, although a portion of it is probably deflected to the Port Royal Railroad, which it intersects at Yemasse.

This city is therefore well supplied with rail communication with the most important portions of South Carolina and the adjacent States.

In anticipation of the demands for larger means of transportation required by the rapid growth of the Southern and Western States, railroad combinations are now in progress with a view of establishing through railway connections between the cities of Charleston, Savan-

nah and other southern ports and the grain region of the great Mississippi Valley.

An important step in this direction will be the proposed extension of the old Blue Ridge Railroad from Walhalla, South Carolina, to the East-Tennessee, Virginia and Georgia Railroad at Knoxville, Tenn. A favorable line of communication will thus be opened via Chattanooga to Cincinnati by the Cincinnati Southern Railroad, and to Saint Louis by the Nashville, Chattanooga and Saint Louis Railroad. A still more direct line will be opened to Cincinnati by completing the Short-Knoxville and Ohio Railroad to a junction with the Cincinnati Southern Railroad.

In a direct line Saint Louis is nearer to Charleston than to any Atlantic port north of it, and with the completion of the contemplated connections, it may be expected that a fair share of the grain and other western produce will seek this outlet.

A necessary condition for securing a proper share of this western business is the improvement of the harbor of Charleston, as the increased trade will require vessels of larger tonnage than have heretofore been able to cross the bar. It is respectfully suggested that the annual appropriations by Congress should bear a just proportion to the magnitude and importance of the works of improvement now in progress, and of the interests to be benefited by their completion.

There is no reason to doubt that the works now under construction will, when completed, maintain a channel across the bar of sufficient navigable depth to satisfy all the requirements of cheap ocean freights.

On similar plans other seaports have been successfully improved. Brief descriptions, with charts, of three foreign harbors, the entrances to which have been deepened by the construction of jetties, are appended to this report, namely: Dublin Harbor, Ireland, Swinemunde, Prussia, and Kurrachee, British India.

This work is located in the collection district of Charleston, S. C., at the port of entry.

Amount of duties on imports collected in 1880, $46,453.98.

The original estimate of cost is a liberal one, amounting to $1,800,000.

Since the plan was approved and adopted, the following appropriations have been made:

By act of Congress, approved June 18, 1878	$200,000
By act of Congress, approved March 3, 1879	200,000
By act of Congress, approved June 14, 1880	170,000
By act of Congress, approved March 3, 1881	175,000
	745,000

Of this amount there has been expended up to June 30, 1881, including outstanding liabilities, the sum of $465,659.55.

The following drawings and papers accompany this report:

Sheet 1, showing the site of the two jetties and recent soundings.

Sheet 2, showing longitudinal section and diagram of widths of north jetty at close of fiscal year.

Sheet 3, showing longitudinal section and diagram of widths of south jetty at close of fiscal year.

Report of Capt. B. D. Greene, Corps of Engineers.

A table of commercial statistics furnished by the collector of the port.

Description of improvement of the harbor of Dublin with chart.

Description of improvement of the harbor of Swinemunde with chart.

Description of improvement of the harbor of Kurrachee with chart.

CHARLESTON HARBOR IMPROVEMENTS.

SHEET I

showing the sites of the North and South Jetties, the progress made in their construction to June 30th 1881 and the present depth on the bar.

From a survey recently made under the direction of

Lieut. Colonel Q. A. GILLMORE, Corps of Engineers U.S.A.

by Capt. B.D. Greene, Corps of Engineers U.S.A.

assisted by

Mr. J.P. Allen, U.S. Ass't Eng'r and Mr. T.H. Fischer

Accompanying annual report dated July 15th 1881.

Q. A. Gillmore
Lt. Col. Engrs. Bvt. Maj. Genl. U.S.A.

The soundings are given in feet and tenths and refer to the plane of Mean Low Water.
The 12 feet curve is marked .....
" 15 " " " " .. .. ..
" 18 " " " " ... ...

FT. MOULTRIE

S U L L I V A N ' S I S L A N D

FT. SUMTER

High Water Line

Low Water Line

Mean Low Water Line

Proposed Jetty

Proposed Jetty

Proposed Jetty

Proposed Jetty

B a r

End June 30th 1881.

End June 30th 1881.

M O R R I S I S L A N D

High Water Line

Low Water Line

Scale of Feet

1000 500 0 1000 2000 3000

Cross Sections of Mattresses
for the jetties in Charleston Harbor S.C.,
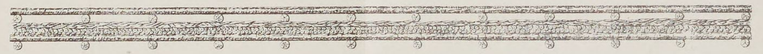
according to specifications accompanying circular letter of September 27th 1880.

Note: Only the 1st and 3d design are given, the 2d is the same as previously used and shown on sheet 2 appendix I, annual report for 1879.

First Design for Mattresses



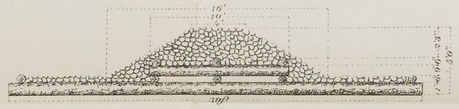
Third Design for Mattresses



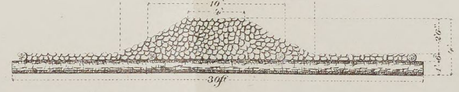
Cross Sections of Spur Jetty

as built at the foot of Laurens street on the south shore of Sullivans Island S.C. in December 1880.

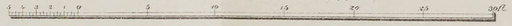
Section showing 2 layers of logs



Section showing 1 layer of logs



Scale for Cross Sections



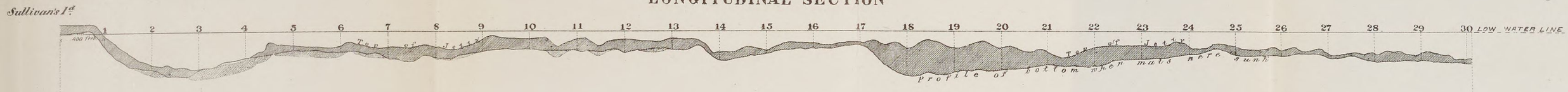
CHARLESTON HARBOR IMPROVEMENTS.

SHEET 2

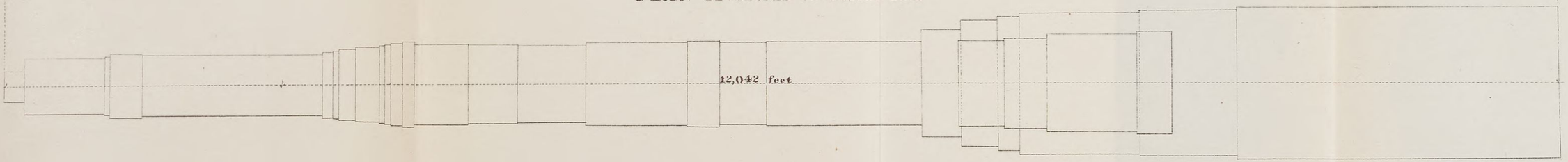
showing section of the North Jetty
and a plan of the mattress at various points as built to June 30,1881
Accompanying annual report dated July 15, 1881.

D. A. Gillmore
Lt. Col. Engrs. Bvt. Maj. Genl. U.S.A.

LONGITUDINAL SECTION



PLAN DEVELOPED ON A RIGHT LINE



Scale of lengths for section and plan

100' 0 500' 1000' 2000' 3000'

Scale of heights for section

10' 0 10' 20' 30' 40'

Scale of widths for plan

40' 20' 0 40' 80' 120' 160'

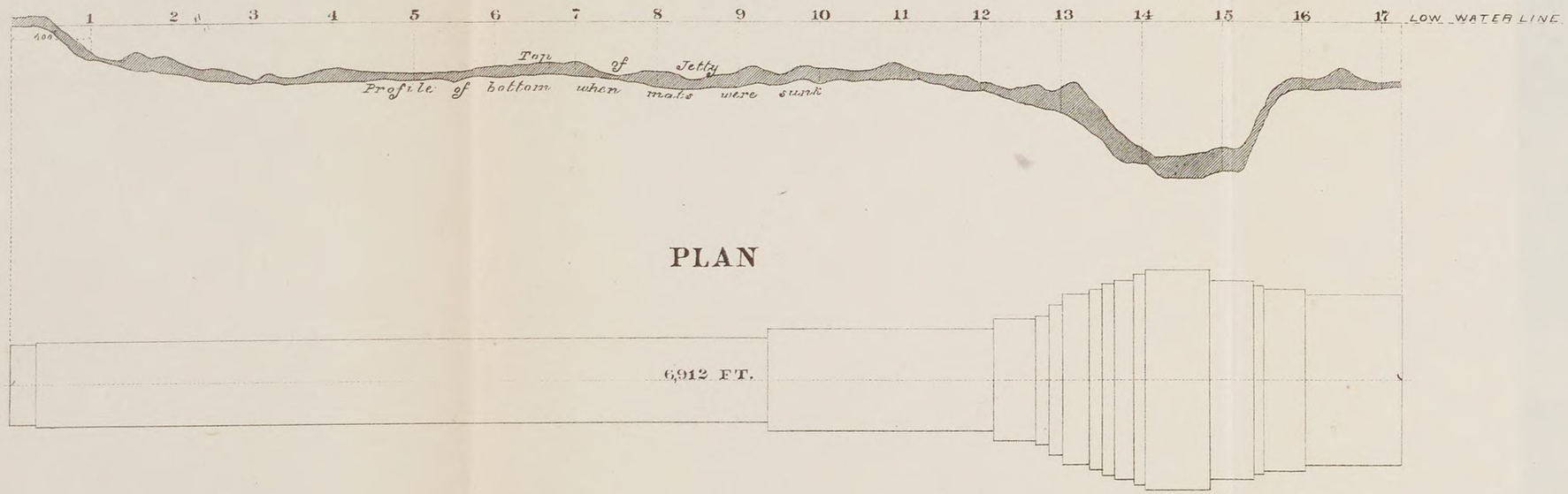
CHARLESTON HARBOR IMPROVEMENTS.

SHEET 3

showing section of the South Jetty
and a plan of the mattress at various points as built to June 30,1881
Accompanying annual report dated July 15th 1881.

O. A. Gillmore
Lt. Col. Engrs Bvt. Maj Genl. U. S. A.

LONGITUDINAL SECTION



PLAN

Scale of lengths for section and plan

100' 0 500' 1000' 2000' 3000'

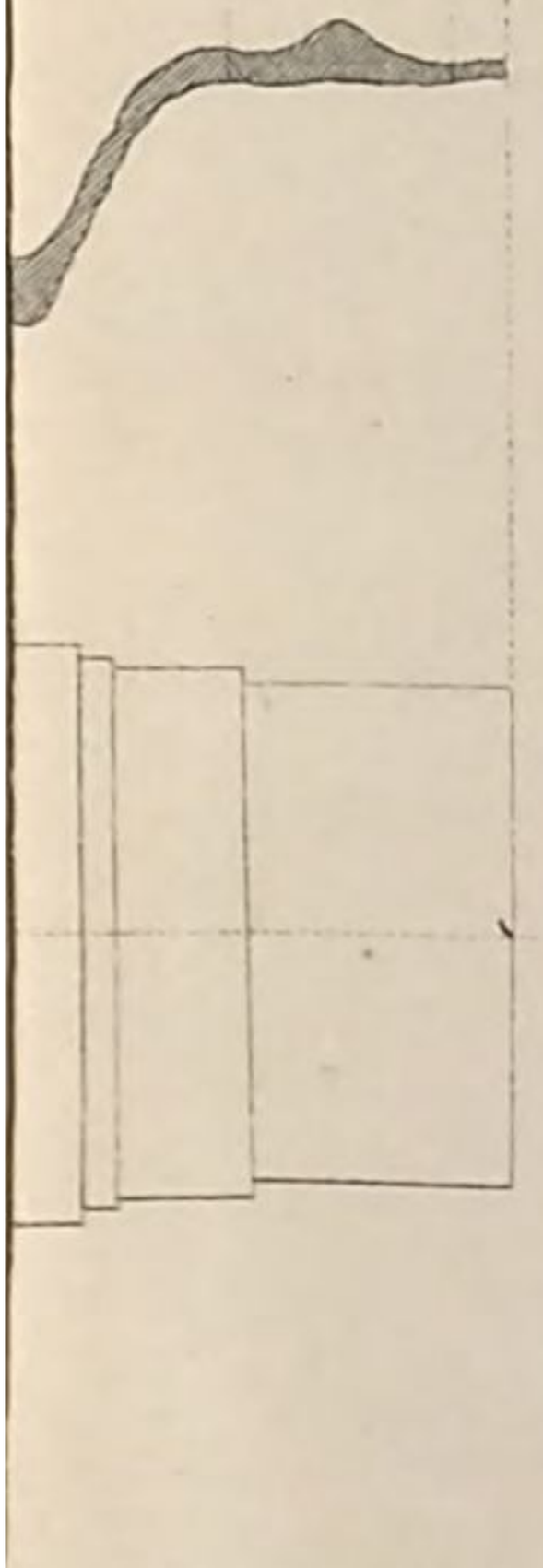
Scale of heights for section

10' 5' 0 10' 20' 30' 40' 50'

Scale of widths for plan

40' 20' 0 40' 80' 120' 160'

S.



Money statement.

July 1, 1880, amount available	$318,759 94	
Amount appropriated by act approved March 3, 1881	175,000 00	
		$493,759 94
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	108,765 45	
July 1, 1881, outstanding liabilities	105,654 04	
		214,419 49
July 1, 1881, amount available		279,340 45
Amount (estimated) required for completion of existing project		1,055,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		750,000 00

Abstract of proposals for riprap stone for North Jetty, Charleston Harbor, South Carolina, opened July 19, 1880.

No.	Bidders.	Price per cubic yard weighing 2,800 pounds.
1	John H. Devereux, jr., Charleston, S. C	$3 20
2	F. P. Murphy, Washington, D. C	2 80
3	R. G. Ross and E. J. Pennypacker, Wilmington, N. C	3 23
4	David V. Howell, New York City	3 37
5	J. J. Shipman, Lewinsville, and H. P. Gilbert, Georgetown	3 95
6	John F. Gaynor and Eli T. Bangs, Fayetteville, N. Y	4 22½

Abstract of contract for riprap stone for North Jetty, Charleston Harbor, South Carolina.

Contractor.	Residence.	Price per cubic yard.	Nature of work.	To commence.	To complete.
F. P Murphy	Washington, D. C.	$2 80	Delivering riprap stone of 2,800 pounds weight to the cubic yard on North Jetty.	September 1, 1880.	June 30, 1881

Abstract of proposals for the construction of jetties in Charleston Harbor, South Carolina, opened September 14, 1880.

No.	Bidders.	Per linear foot of mattress 54 feet wide, overlaid with 1 foot of riprap stone.			For riprap stone of 2,800 pounds to the cubic yard.
		First design.	Second design.	Third design.	
					Per cu. yd.
1	John Brady, Brooklyn, N. Y	$13 90			$3 50
2	Anderson & Blaisdell, Boston, Mass	12 00	$12 50	$11 90	3 50
3	O. J. Jennings, Fulton, N. Y	16 00			2 00
4	F. P. Murphy, Washington, D. C., and A. S. Law, Staunton, Va.				3 28
5	Nicholas A. Devereux, Charleston, S. C	12 00			3 30
6	E. T. Bangs and Moses Dolbey, Fayetteville, N. Y.	12 45			3 95

Bids rejected and new proposals invited.

Abstract of proposals for the construction of jetties in Charleston Harbor, South Carolina, opened October 16, 1880.

No.	Bidders.	Per linear foot of mattress 54 feet wide, overlaid with 1 foot of riprap stone for either of the three designs.
1	Nicholas A. Devereux, Charleston, S. C	$10 73
2	John Brady, Brooklyn, N. Y	11 00
3	Moses Dolbey, Moultrieville, S. C	11 75

Abstract of contract for construction of jetties in Charleston Harbor, South Carolina.

Contractor.	Residence.	Nature of work.	Price per	To commence.	To complete.
Nicholas A. Devereux..	Charleston, S. C.	Laying courses composed of logs and brush overlaid with 1 foot of riprap stone.	$10 73	Feb. 5, 1881.	Dec. 26, 1881.

Proposals for continuing work upon the jetties in Charleston Harbor, South Carolina, opened December 11, 1880.

No.	Bidders.	Per linear foot of mattress 54 feet wide, overlaid to the depth of 1 foot with riprap stone of 2,800 pounds to the cubic yard.	To commence.	To complete.
1	Moses Dolbey	$13 45	On or before May 1, 1881..	On or before June 30, 1881.

Contract awarded at the price stated; completed June 30, 1881.

Abstract of proposals for continuing the construction of jetties in Charleston Harbor, South Carolina, opened May 9, 1881.

No.	Bidders.	For mattress.	For riprap stone.	To commence.	Monthly progress.
		Per sq. yd.	*Per cu. yd.*		
1	John Brady, Brooklyn, N. Y	$1 19	$3 00	July 1, 1881 ..	$23, 000
2	John G. Smith, Charleston, S. C.	1 25	3 25	.....	.....
3	Eli T. Bangs, Fayetteville, N. Y	70	3 70	July 1, 1881 ..	Average $23, 000.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Charleston, S. C., from January 1, 1875, *to December* 31, 1880.

VESSELS ARRIVED.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1875	504	382, 018	11, 649	38	13, 144	326	198	88, 879	2, 404	740	484, 041	14, 379
1876	471	340, 439	10, 113	44	11, 898	335	224	101, 272	2, 768	739	453, 609	13, 216
1877	400	324, 919	9, 885	32	13, 972	308	236	105, 480	2, 851	668	444, 371	13, 044
1878	399	322, 527	9, 623	44	19, 935	455	329	163, 368	3, 967	772	505, 830	14, 045
1879	383	326, 681	10, 027	39	12, 505	319	246	121, 503	3, 292	668	460, 689	13, 638
1880	441	388, 026	10, 641	38	12, 412	327	191	110, 771	2, 595	670	511, 209	13, 563

VESSELS CLEARED.

Year.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
1875	461	328, 266	10, 830	57	24, 679	555	211	94, 595	2, 527	729	447, 540	13, 912
1876	431	278, 744	9, 095	60	23, 598	546	230	103, 276	2, 812	721	405, 618	12, 453
1877	335	234, 429	7, 719	35	22, 767	423	250	108, 446	2, 910	620	365, 662	11, 052
1878	266	172, 988	5, 801	45	24, 397	479	398	149, 975	3, 591	509	347, 360	14, 045
1879	287	188, 212	6, 268	34	11, 282	292	278	149, 052	3, 643	599	348, 546	10, 203
1880	296	190, 733	6, 348	45	23, 210	481	246	155, 768	3, 375	587	369, 711	10, 204

Year.	Value of exports.	Value of imports.	Duties collected.
1875	$19, 655, 966	$680, 343	$80, 656 00
1876	18, 088, 152	455, 562	89, 168 00
1877	16, 917, 492	161, 237	46, 848 00
1878	21, 167, 575	184, 127	36, 990 00
1879	18, 693, 126	127, 981	24, 070 00
1880	24, 939, 259	248, 158	46, 453 98

C. H. BALDWIN,
Collector.

REPORT OF CAPTAIN B. D. GREENE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., July 12, 1881.

COLONEL: I have the honor to submit the following report of progress of the work upon the jetties in Charleston Harbor for the fiscal year ending June 30, 1881:

The work of the past year has been entirely given to the extension of the foundation courses of the two jetties. A small amount of the rock, however, was placed upon the north jetty where the foundation had been previously laid, viz, the portion immediately east of Drunken Dick Shoal. This work was done under a supplementary contract, and the contractor failed to perform the work as required by the agreement.

An examination of the locality, made in March, showed that there was no real difficulty in the way of closing the gap known as Drunken Dick Shoal, on the line of the north jetty. This work was accordingly done in April and May.

The following statement shows the lengths of foundation courses of the two jetties constructed during the fiscal year, and the total lengths on the 30th of June:

NORTH JETTY.

	Feet.
Outward extension during the year	2,725
Closing gap across Drunken Dick Shoal	1,663
Total length foundation course laid during year	4,388
Length reported at date last report	7,654
Length foundation course June 30, 1881	12,042

SOUTH JETTY.

Outward extension foundation course	4,362
Length reported at date last report	2,550
Total length foundation course June 30, 1881	6,912

Of the above, reported as done during the year, the portion across Drunken Dick is not complete, some 4,000 yards of rock being required to make it secure.

During the coming year the foundation course of the north jetty will probably be completed, and that of the south jetty extended some 3,000 feet or more. Considerable progress will also be made in raising the north jetty. As the work is now going on, all the money available will be expended before the end of the current year.

So far as appears upon an examination by sounding, the foundations have stood well. The north jetty has, perhaps, settled a little in some places, as across the Beach Channel at one or two points, but not to a very considerable extent. It should be remembered that at present the foundation is wide in proportion to the weight borne by it; that a great part of it has been laid upon shoals where the bottom has been pounded by the sea, and that the work is not yet brought high enough to have any appreciable effect upon the direction of the currents.

I have arranged to have the entire foundation examined carefully by a diver at an early day, and the result of this examination, together with some facts relating to the velocity and direction of the tidal currents in the vicinity of the works, will be reported to you during the fiscal year.

In accordance with the general instructions received when I reported to you for duty, in March last, arrangements have been made for careful and minute examination of the bar near the jetties, from time to time, with a view of observing the effect of the work both for information and guidance.

The tracing accompanying this report is the first of these partial sketches which will show the progress of the works, their effect, and the difficulties in the way of their success. It may be said, once for all, that the stations indicated as occupied in the location of points on the bar have been connected by an accurate system of triangulation, and their position has been determined very closely. I have no maps of later date than the Coast Survey Charts with which to compare this last survey. The soundings upon the Coast Survey Charts were taken in 1865. In this interval of sixteen years there have been considerable changes in the shores about the outer harbor, and in the shape and position of the minor portions of the bar.

The shores of Sullivan's Island are going away rapidly, and each year the sea is encroaching upon portions of the island that were once at a safe distance from the extreme high-water mark.

The removal of the Bowman's Jetty in part accounts for this, no doubt, and it is very probable that the north jetty on the bar may have increased the current of the tide in storms, and caused it to work with greater violence upon the shore.

Morris Island has been cut away on its eastern side some 500 feet, and in a short time the sea will undoubtedly break through the narrow strip of sand and marsh that remains.

This action of the sea and currents is now going on more rapidly than ever, and should receive immediate attention.

This sand removed from these shores is deposited further up the harbor and shifts about, requiring constant provisions against the formation of shoals in the vicinity of exposed landings, as at Fort Sumter, and perhaps finally may work out toward the mouth of the harbor and have to be removed at considerable cost. It is true, here as on a river, that the preservation of the shores is an important step.

The approximate positions of such short jetties as seem to be needed on these two islands are indicated on the tracing. These works are estimated to cost from $1,500 to $2,000 each, and the expenditure of $10,000 of the present appropriation in their construction would, I think, be wise economy.

In this place it may be proper to say that the practice of dredging the slips between the wharves along the city front and dumping the material just outside the pier-head line has prevailed for some years past. Looking to the preservation of the inner har-

bor while the government is expending large sums for the improvement of the entrance to it, the question of the disposition of this material in such way as to be inexpensive and at the same time effective has been considered. I am glad to say that as soon as brought to the attention of the city authorities, in whose hands lies the power to remedy this evil, their action was prompt and well advised. Under their order and until further permission is granted, all such material must be dumped in the bay south of the line of "Shutes Folly Island" north, and "Hog Island" south.

Referring to the changes that have taken place on the bar within the last sixteen years, they are of such a nature that they have probably been gradual. With the exception of a few soundings taken about the site of the north jetty before its construction commenced we have no data for the determination of the position of the shoals at any immediate time.

It does not appear to me that it could reasonably have been expected that any marked effect should have been observed from the jetties in their present stage of progress. It is very plain that, unaided by dredging, the channel will necessarily form between the two shoals marked A and B. This channel will not form until the south jetty is well advanced. Looking to the great depth of water in the main ship channel and the adjacent deep pool, it will be some time before the work is sufficiently advanced to materially effect this part of the bar. To make a channel with either jetty mainly, it seems that in the one case an opening must be made through the shoal A, and in the other through the bar B. Two approximate locations of the outer end of the south jetty are indicated upon the map. One of these gives an opening of 2,000 feet and the other of 2,600.

The second, as I understand, is about what was originally contemplated, and seems to cross the shoal B on a very fair line. Considering the advance of the north jetty, it appears that the shoal A should be selected for removal first. As the jetty is raised the current will naturally tend to draw through a cut parallel to it. Whether this cut can be made, and whether the current will maintain it, unless protected from the heavy southeast seas by the south jetty are questions that cannot be positively determined in advance.

When I arrived here in March the dredge Henry Burden had recently come up from the Savannah River. After an examination of the bar I submitted for your approval a sketch indicating the area to be dredged, as shown on the tracing. This bar, like the shoal B, is composed apparently of sand, with occasional shells imbedded. These shoals move about very slowly. The sea usually breaks upon them, and this action makes them hard. There is nothing, however, in the nature of the material that renders their removal difficult. Their exposed position is the great obstacle. This being the case, a machine to work at them should be able to stand tolerable severe sea, should work rapidly when engaged, besides should stir up considerable material that the current may move along when once established. The Henry Burden was found to be only partially successful in any of these particulars, and in accordance with your instructions she was sent back to the Savannah River, where she has been reported to have done good work in previous years.

From the inquires I have been able to make, it seems probable that a dredge can be built that will work successfully on these shoals, or that a contract can be made for their removal. It is probable that the dredge will cost about $50,000. Some arrangement for work of this kind in the immediate future seems a necessity.

The importance of a larger annual appropriation for this work is so evident that it scarcely seems necessary to refer to it. The construction is now so far advanced that a very large annual expenditure is practicable with a reasonable expectation of benefit therefrom at an early day.

Mr. J. M. Walbrect, assistant engineer, is in charge of the work of construction. He is assisted in the inspection and measurement of materials by Mr. W. H. Porter. James P. Allen, assistant engineer, has the charge of the examinations and surveys on the bar here, and other works in the vicinity. He is assisted by Mr. T. H. Fisher.

All these gentlemen deserve credit for the zeal and intelligence with which they have performed the duties intrusted to them.

Respectfully submitted.

BENJ. D. GREENE,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

DESCRIPTION OF DUBLIN HARBOR, IRELAND.

Dublin Harbor furnishes a striking illustration of the successful application of jetties for the improvement of a bar-channel.

The city of Dublin is situated on the eastern shore of Ireland, at the head of the Dublin Bay, on both sides of the river Liffey. The river is navigable to the center of the city.

The Liffey is an insignificant stream, very crooked, its total length being 82 miles, but only 13 miles in a straight line. Its drainage area is 476 square miles, its mean discharge about 850 cubic feet per second.

Two smaller streams, the Dolka and Dodder, also discharge into the bay at Dublin, their aggregate water-shed being 108 square miles.

Dublin Bay is formed by the projection into the Irish Channel of the promontory of Howth on the north, and the highlands of Dalkey, Sandycove, and Kingstown on the south.

At the head of the northwestern end of the bay, in front of the city of Dublin, are two extensive sand banks, named, respectively, the North and South Bull, between which the river Liffey is discharged.

From the constant encroachments of these banks the navigable portion of the river was very defective, and the bar channel greatly obstructed. The bar is composed of moderately fine sand.

The mean range of tide is about 8 feet 10 inches. The first important step to improve the entrance to Dublin Harbor was taken about the middle of the last century.

To prevent the shifting sands of the South Bull from moving toward and into the channels of the river and bar, a substantial jetty or groyne was commenced to be built in 1748, termed the Great South Wall. It defined the southern border of the river, and extended eastward from the city to the bar. Its total length is about 3 miles.

This wall originally terminated at the Pigeon House Fort, where a small harbor was subsequently constructed for vessels; its length to that point was about 1½ miles.

In the years from 1761 to 1768, it was extended a length of about 1½ miles more to Poolbeg, where the light-house of that name stands, forming the eastern extremity of the Great South Wall.

The top of this wall is about 6 feet above high-water level except the outer end for half a mile in length, which is 4 feet higher. Still the sea breaks freely over this high portion during the prevalence of gales from the south and southeast.

The older half of this work consisted of two parallel rubble walls, with an outside batter of about 1 upon 10, their faces being from 37 to 48 feet apart. The space between the walls was filled with débris, chiefly sand and gravel. Both face walls were crowned with massive stone parapets, 4 feet high and 2 feet thick, the roadway between them being at a level of 6 feet above high-water.

The outer or later 1½-mile length of the south wall was built as a solid dry rubble wall, faced on both sides and on top with granite ashlar in long pieces, bonded but laid dry except on the top, where the joints are pointed. The sides have a batter of $\frac{1}{12}$; the ashlar courses being laid with vertical faces and horizontal offsets.

The Great South Wall did not produce any sensibly beneficial effect on the bar. It protected the river from the encroachments of the South Bull, and acting as a training wall, it confined and diverted the tide currents in the direction of the river channel, which was thereby slightly deepened. The seaward portion of the river was sheltered by it from the south and southeast winds.

The condition of the channel across the bar and of the river leading to the city was still far from satisfactory after the southern wall had been built. On the bar there was only 6 feet depth at low-water, and several portions of the river had depths of only 2 or 3 feet.

The problem of further improving the harbor was first seriously taken up at the beginning of the present century, and several of the most distinguished British engineers were requested to furnish plans and reports on the subject.

Some of these engineers considered the difficulties of improving the harbor so formidable that they advised the construction of an entirely new harbor on the shores of Dublin Bay, some distance from Dublin, connecting with that city either by ship canal or railway.

In 1818, the port corporation of Dublin finally decided to have recourse to the most simple expedient for improving the harbor, which consisted in constructing a pier on the north side of the entrance, and termed the Great North Wall.

The leading objects to be gained by this work were: To shelter the harbor; to prevent the sand passing from the North Bull into the harbor; and to admit as great a body of tide water as possible into the harbor, and return the same to sea past the Poolbeg light-house, within such limits and in such direction as would produce the best scouring power on the bar with the least obstruction to the navigation.

The Great North Wall commences from a point on the Clontarf or north shore, about 7,300 feet north of the Great South Wall. Its direction is about south 50½ degrees east; if produced it would intersect the south work at an angle with it of about 39½ degrees. The North Wall is straight from end to end. Its total length is about 9,000 feet. Its crest is established at a level of 6 feet above high-water for a length of 5,600 feet from the shore, and then drops down to about high-water level, and beyond that gradually descends to the outer end of the jetty, where it is only about one foot above low-water.

The width of the gap between the heads of the two walls or jetties is about 1,000 feet. The mode of constructing the Great North Wall was quite simple. Large and small riprap stones were thrown on the bottom of the bay, where they were allowed to

BA

MENT

dated

Ga.



CHART OF DUBLIN BAR

WITH DETAILS OF WORKS OF IMPROVEMENTS.

Sent with report on Charleston Harbor Improvement, dated July 15th 1881.

Q. A. Gillmore
Bvt. Col. Engrs. Bvt. Maj. Genl. U.S.A.



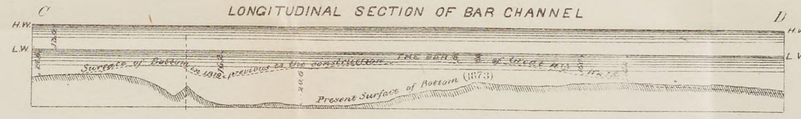
SECTIONS OF GREAT SOUTH WALL EASTERN PART

SECTIONS OF GREAT NORTH WALL ON LINE A

WESTERN PART

ON LINE B.

LONGITUDINAL SECTION OF BAR CHANNEL



SCALES
Horizontal
Vertical

find their own foundation by settling. The smaller stones consisted chiefly of limestone, the larger ones of granite quarried in the vicinity. Where practicable, the material was dumped from carts, otherwise it was transported and sunk from small sailing vessels.

The top width of this riprap work is about 30 feet. The side slopes vary now from 1 upon 2 to 1 upon 4.

This work was begun in 1819 and finished in 1825. Before speaking of the effects of the two works, a few remarks may be made.

In 1819 the harbor was approached by two shallow channels, of which the deeper but less direct was formed by the scour of the flood tide, and the other by that of the ebb.

The bar, which in 1819 blocked the entrance, consisted of a flat sandy shoal, the western end of which was about 500 feet east of Poolbeg light-house, whence it extended in an easterly direction nearly 5,000 feet.

The flood channel passed between the South Bull and the western terminus of the shoal, with a minimum low-water depth of 8 feet 6 inches. This channel was then and is still kept open by the scour of the flood tide, which enters Dublin Bay from the southeast and sweeps around the edge of South Bull.

The bar channel proper, or the ebb channel, had a direction east by south, with a minimum low-water depth of 6 feet 6 inches.

AREA AND VOLUME OF BACKWATER.

The estuary composed of the two jetties, including the tidal portions of the two rivers, is a little over 4 square miles. A little less than 1 square mile of this area is below low-water; the remainder averages $3\frac{1}{2}$ feet above low-water. The average quantity of water flowing into and discharged from the estuary is estimated at about 24,000,000 tons per tide each way, or about 31,600,000 cubic yards.

WIDTH AND VELOCITY OF DISCHARGE.

From the description given of the longitudinal profile of the North Wall it follows that the width of the opening through which the water is discharged, diminishes as the tide falls. At the commencement of the ebb the width is 4,000 feet, the water flowing over that part of the jetty which is below high-water; near low-water the outlet is narrowed to rather less than 1,000 feet; the effluent stream being confined between Poolbeg light-house and the extreme end of the North Wall.

The object to be attained by terminating the higher portion of the wall at so considerable a distance from the southern side of the entrance was apparently to avoid producing such a current as would be injurious to navigation; a greater velocity than 4 miles per hour at the entrance to a harbor being undesirable and liable to cause inconvenience if not danger, particularly to sailing vessels.

The main ebb current, as defined by the deepest channel, flows over the bar in a direction east one-half south, frequently attaining a velocity of $3\frac{1}{4}$ miles per hour. The greatest velocity generally occurs at half-ebb of high spring tides, and in all cases decreases considerably as the stream spreads and enters the deep water east of the bar.

RESULTS.

In regard to the benefits to navigation, it is stated that in 1835 the largest vessels that could enter the harbor rarely exceeded 400 tons register, while in 1879 vessels of 1,600 tons register, carrying usually 2,200 tons of cargo visit the place, with a draught of 22 feet. Coasting vessels of 13 to 14 feet draught can now enter or leave the port at the low-water stage.

The tonnage annually entering the port has almost steadily increased since the Great North Wall was completed. In 1825 it amounted to 396,053 tons, in 1877, 1,973,781 tons.

The progress of scour has been more or less continuous since 1822, when the North Wall was not yet completed. Relatively the greatest effects were obtained in the first six years, from 1822 to 1828, as shown by the following table, which gives the least depth on the bar observed in different years:

Date.	Minimum depth on bar at low-water.	Interval.	Increase of minimum depth.	Rate of increase of minimum depth per year.	Depth on bar at standard high-water.
	Ft. In.	*Years.*	*Ft. In.*	*Inches.*	*Ft. In.*
1822	6 3	.....	.....	.....	19 3
1828	9 6	6	3 3	6.50	22 6
1833	10 6	5	1 0	2.40	23 6
1856	13 0	23	3 6	1.81	26 0
1873	16 0	17	3 0	2.11	29 0

A gradual deepening of the bar channel is still going on, due mainly to the action of the ebb currents. But the flood tides, running in an opposite direction at about the same velocity as the ebb, produces similar results, and it is thought that the great increase of depth in the western portion of the bar channel can be ascribed to the joint action of both ebb and flood currents. It is believed that the material removed by the scour of the flood currents has caused the formation of a bank (Mumble's Bank) west, and inside of, the harbor mouth, south of the channel. This bank accumulates at the rate of from 7,000 to 8,000 cubic yards a year, which is removed by dredging every other season.

Mr. I. J. Mann, civil engineer, from whose elaborate discussion of the improvement of Dublin Harbor the foregoing data are taken, says that the deepening produced by the scour of the flood current after passing through the entrance into the estuary is but inconsiderable compared with the corresponding effect of the ebb current after its passage through the entrance to the bay, and ascribes this great difference to two causes, to wit:

1. The flood tide approaching the entrance from different directions almost immediately after entering the estuary expands over a large area, while on the other hand, the ebb stream, particularly the latter half, has a definite direction imparted to it before passing into the bay, by which it is kept together and its energy concentrated.

2. The flood current enters comparatively still water, and an area so sheltered that waves of sufficient size to affect the bottom are seldom generated; whereas the action of the ebb current is considerably enhanced by the agitation of the sandy bottom, produced by waves, the generation of which is favored by the exposed position of the bay.

DESCRIPTION OF HARBOR OF SWINEMUNDE ON THE BALTIC SEA.

Several harbors on the Baltic Sea have been improved by means of jetties.

Perhaps the most successful example of this method of improvement is shown at the entrance to the harbor of Swinemunde, the out-port of the city of Stettin, an important commercial town of Prussia.

Stettin is situated about 40 miles from the sea, on the left bank of the river Oder, which here flows into the "Stettin See," or "Haff," a lake-like expansion of the river, with about 200 square miles of water surface, and depths varying from 12 to 18 feet.

The total drainage area of the Oder is estimated at 50,000 square miles.

The Haff is separated from the Baltic by the islands of Usedom and Wollin, and is connected with it by three straits, or branches, named the Peene, the Swine, and the Divenow. The Swine, which has a length of about 11 miles, is the most important of these outlets, and it is estimated that of the entire water capacity of the Haff, about 170 square miles, or 85 per cent. of the whole, may be regarded as directly tributary to the maintenance of the Swine strait.

The port of Swinemunde is located on the island of Usedom, on the left bank of the Swine, and near its entrance into the Baltic.

The waters of the Oder passing by Swinemunde carry very little solid matter in suspension, even during floods. The extensive Haff acts as a stilling basin, and receives the deposits brought down by the river.

The Baltic is practically a tideless sea, but although there exists no succession of ebb and flood tides, the currents of which would tend to create and preserve a navigable channel of entrance, the depths actually produced at Swinemunde are considered to be due more to the action of the sea than to the fresh-water discharge of the river proper.

During strong northerly and northeasterly winds, which are of frequent occurrence in this locality, large volumes of sea water are driven through the straits of the Haff, raising its surface as high as 3 feet above the sea level, and banking up the river water in the lower reaches of the Oder.

With the ensuing calm, and more especially by the agency of southerly winds, currents of considerable strength are developed in the seaward discharges of the accumulated waters, lasting several days in succession.

If the southerly winds possess considerable force, the currents in the Swine are especially strong, for the reason that the waters of the Haff are piled up thereby, at the southern end of the strait, while the sea level is depressed by the wind at the seaward entrance, thus producing a steep outward slope and a corresponding current in the strait.

The shores of the Baltic are swept by a littoral current. It runs eastward in front of the entrance to Swinemunde and of the Prussian coast generally, thence northward along the Russian coast, and after crossing the northerly portion of the Baltic takes a southerly direction along the eastern coast of Sweden.

This current being of moderate strength, is frequently destroyed or checked by con-

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MAP O

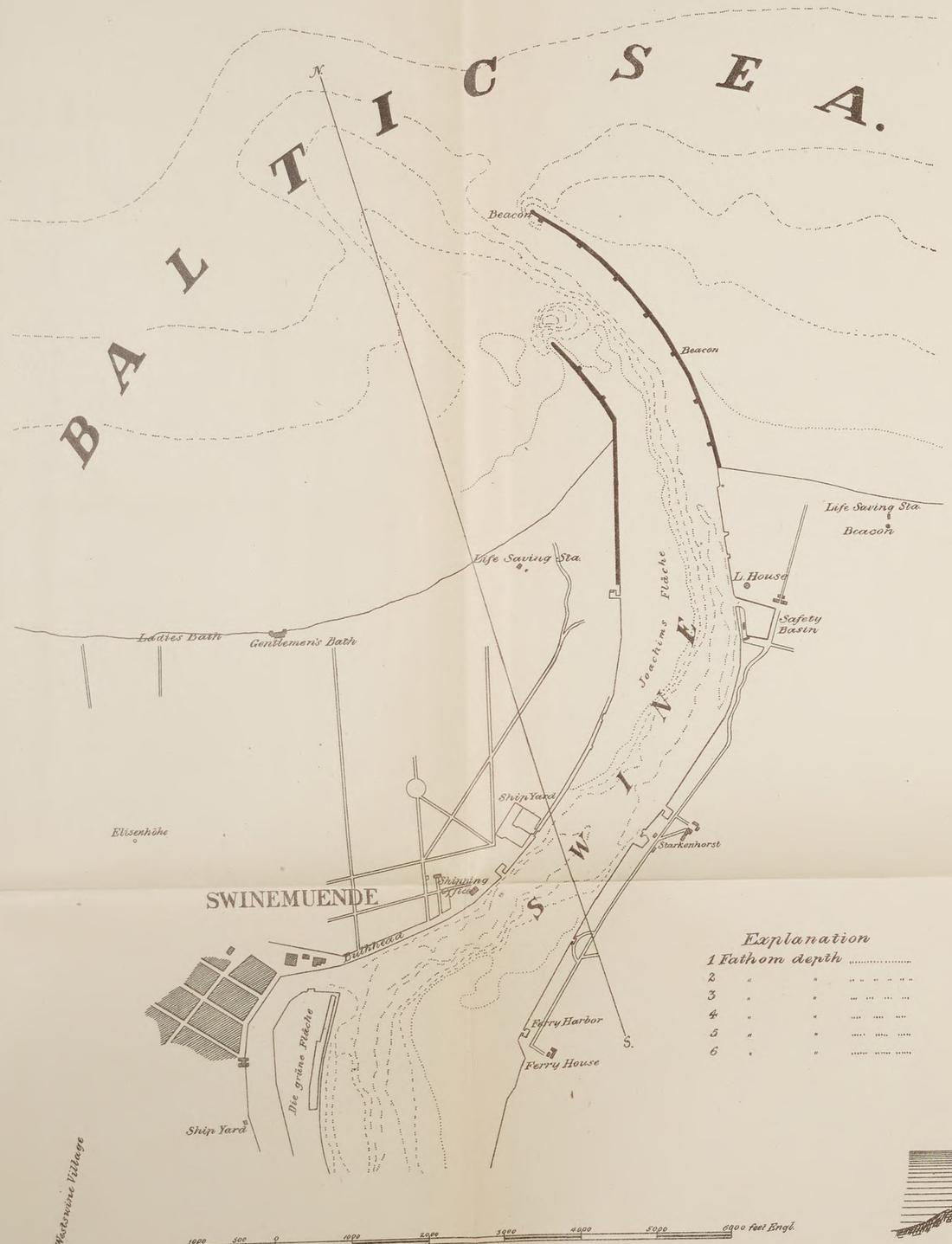
PLAN AND DETAILS
OF THE
HARBOR OF SWINEMUNDE
PRUSSIA

ACCOMPANYING ANNUAL REPORT OF JULY 15TH 1881.

ON CHARLESTON HARBOR IMPROVEMENT

Q. A. Gillmore
Lt. Col. Engrs. Bvt. Maj. Genl. U. S. A.

PLAN SHOWING JETTIES OF THE HARBOR



Explanation

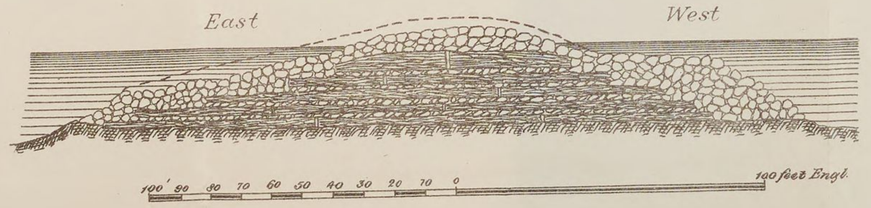
1 Fathom depth .....
2 " " .. ..
3 " " ... ...
4 " " ....
5 " " ....
6 " " ....

MAP OF STETTIN HAFF AND VICINITY



Cross Section

taken near the head of the East Jetty



trary winds. Its power of transporting sand and other sedimentary matter is not so great at Swinemunde as at many other localities on the Baltic coast.

The west pier or jetty was designed to arrest the progress of the sand brought to the entrance by the littoral current, besides confining the currents of the outflowing waters. That it has been effective in that respect is shown by the filling up of the large triangular space, west of the west jetty, the land end of which is now far inshore.

The well-known fact that near concave banks the currents of flowing water generally create and maintain a deep channel, induced the designer of the Swinemunde jetties to construct them on a curved plan, to secure ample depths, at least, on one side of the entrance channel.

Moreover, by adopting this form no violent change in the direction of the flow was introduced. The northwesterly course of the stream, as it had existed for many years previously, was followed in locating the works, the east jetty being made concave on the west side next to the channel.

The two jetties are of unequal length, the east jetty overlapping the west jetty about one-quarter mile, thereby securing the improved channel and the interior of the harbor against the effects of the heaviest storms—those from the northeast.

The curved plan proved entirely successful, inasmuch as considerable depths were produced next to the east jetty; in fact, the opinion has been expressed that a more gentle curvature might have been better, as the depths in the concave bend are actually greater than needed, while on the opposite side extensive shoals are found, necessarily reducing the width of the navigable channel and requiring the frequent use of dredging machines.

The width of the entrance opposite the head of the west jetty is about 1,100 feet, but only about one-third of that width is available for vessels drawing 18 feet.

As a general result of this improvement it is reported that the principal channel in which the depths were only 7 to 7½ feet before the works were begun now has a navigable depth of more than 20 feet, which has been maintained for nearly half a century.

The steamers of the "Stettin Lloyd" running between New York and Stettin are limited to 17 feet draught, not for lack of depths at the entrance, but because a greater draught cannot be safely carried through the Haff and the river Oder to the city of Stettin.

It will be seen from the accompanying plan that the mouth of the entrance is turned towards the littoral current, which may appear to be somewhat remarkable on the supposition that the overlapping part of the east jetty would act as a catch for the drifting sand moved by the shore current.

It has been proved, however, that the outflowing currents are of sufficient strength to keep open a good channel in front of the entrance.

Of late the question has been raised, whether it would be advisable to continue the jetties on the curve adopted, whenever it should become necessary to extend them. It is obvious that an extension on such a plan, if sufficiently long, would finally turn the mouth entirely shoreward, which would be impracticable. It has been, therefore, proposed to extend the east pier on a reverse curve, directing the current to the north-northeast, and in prolonging the west pier, bringing it nearer to the east pier. By these means it is expected that the entrance would be protected from deposits of sand, moved by the prevailing northwest winds and littoral current, which chiefly cause the necessity of dredging, and that the seaward scour would be maintained or increased.

The Swinemunde jetties were constructed of alternate courses of brush mattresses and rubble-stone, as shown in the cross-section of the east jetty, taken near its head in 1858.

The broken line shows the original profile. Since that time, through compression of the several courses of mats, the crown has settled still lower than represented in the figure.

The average width of the jetties at the water line is 60 feet. The crown and adjacent portions of side slopes were paved or revetted with heavy granite blocks.

The frequent damages to this pavement necessitated repeated repairs to restore the height. A marked modification of the original cross-section has been brought about by the formation of a wide berme, on the harbor side, caused by the deposit of masses of stone carried across the crown from the outer slope, by the force of the waves.

The construction of this work, commenced in 1819, was completed in 1829.

Seven years later it was considerably damaged, and before it was thoroughly repaired, another heavy northeast gale caused extensive injuries. Great quantities of paving and rubble-stone were carried off, leaving the mattresses exposed. The stones were generally thrown in large piles upon the inner slope.

An attempt was made to secure greater stability by connecting rows of stone with strong iron and wooden dowels, but it failed, the least motion destroying the connection. Even granite blocks of 4 tons weight, and cement blocks still heavier, did not

resist the shock of the waves produced by strong northeast gales, and were thrown over the crown.

The head of the jetty is now paved with cut stone, at a slope of 1 to 8, and is protected by rows of very large blocks of granite. Although more recent gales have shown that full security has not yet been attained, the damages produced are on the whole of more moderate extent than heretofore.

DESCRIPTION OF KURRACHEE HARBOR, EAST INDIES.

Kurrachee (see accompanying chart) is the principal town and sea-port of the province of Sinde, the most westerly harbor of the British possessions in the East Indies. It is situated on the northern border of the Arabian Sea, and about 50 miles west of the principal pass of the Indus River Delta. The mouths of this delta being barred by sand banks, Kurrachee may be considered as the transfer point for traffic on the Indus.

The general trend of the coast is northwest and southeast.

Violent storms are unknown here, but the southwest monsoons, blowing directly toward the coast, from the middle of June to the middle of September, bring on very heavy seas, owing to a sweep of about 500 miles over a deep-sea bottom. At such times the waves in deep water just outside the entrance into the harbor attain a height of 15 feet from hollow to crest, traveling at the rate of 30 miles per hour.

The average range of spring tides is 9 feet 6 inches, with occasional oscillations as great as 12 feet. The mean range of neap tides is from 3 to 4 feet.

Kurrachee is a strictly tidal harbor, the only river discharging into it, the Layari, flowing only for a few days each year, when heavy rains fall in the hills. Even at those times, although it has considerable volume and brings down a large quantity of sand, it is said to have no appreciable effect, favorable or otherwise, on the regimen of the harbor.

The maintenance of the harbor is chiefly due to the existence of a large area of backwater. A shallow marshy basin in close proximity to the harbor and covering an area of about 18 square miles at high-water of spring tides, acts as an immense natural scouring basin.

The harbor is separated from the sea by a reef about 10 miles in length, running in a northwesterly direction and connecting at its northerly end with the mainland. The sea has formed a beach along this reef, topped by a ridge of sand. The southeasterly end of the reef is a headland of 90 feet height, known as Manora Point. This point, forming the right bank of the lower harbor, consists of stiff clay capped by conglomerate rock, large masses of which have fallen off and help to protect the base of the cliff. A light-house occupies the extremity of Manora Point.

The left bank of the harbor, for a distance of about 2 miles, is formed by a sand spit, to the eastward of which lies a shallow bay, about 3½ miles in width.

From Manora Point the "bar" runs in an easterly direction.

The former main channel, of 14 feet low-water depth, rounded the spit about 1,000 yards from Manora Point, while a minor west channel of 11 feet depth existed nearer to the point at about the same place where the new channel has been found. These old channels were much exposed to occasional shoaling from the effects of the monsoons.

The bar is formed chiefly of sand, but near the point occur small patches of sandstone rock, bowlders, and shingle.

Before the improvements were made, the head of the bay lying to the eastward of the entrance was connected with the backwater of the harbor by means of Chinna Creek, so that in point of fact there were two outlets to the tidal basin.

The first works of improvement, commenced in 1843, soon after the British conquest of Sinde, comprised a timber pile pier at Keamari and the Napier Mole, a solid and broad causeway of earth about 2 miles long, extending from the westerly end of Keamari to near Kurrachee on the mainland. This road facilitated traffic between the town and the shipping at Keamari, but it was considered to be injurious to the harbor for the reason that it excluded from it the waters of the eastern or smaller portion of the tidal basin, and allowed them to escape directly into the bay through the mouth of Chinna Creek.

In 1859, Mr. James Walker, of England, submitted a project for improving the harbor and channel of approach, comprising the works named below, which have been constructed substantially as described.

1. *Manora Breakwater*, extending from Manora Point on the west side of the entrance, in a direction south by east one-quarter east, for a length of 1,503 feet, terminating in a low-water depth of 30 feet. This work was designed to shelter the entrance from the violent and dangerous seas caused by the southwest monsoons, and to pro-

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PLAN
OF
KURRACHEE HARBOUR
1879
ACCOMPANYING ANNUAL REPORT OF
JULY 15TH 1881.
ON CHARLESTON HARBOR IMPROVEMENT
Q. A. Gillmore
Lt. Col. Engr. Bvt. Maj. Gen.
H.W.M.
High Water Mark
Low Water Line
NOWA NAL
BABA
Baba Creek
Pulri Creek
Sih Creek
WATER
BACK
ARABIAN SEA
NATIVE JETTY
TOWN
CANTONMENT
STATION
Trinity Chuch
Government House
Frere Hall
RAILWAY TO KOTREE
RAILWAY WORK SHOPS
BRIDGE
NEW CHANNEL WEST
NEW CHANNEL EAST
BACKWATER
KEAMARI ISLAND
RAILWAY
CHINNA CREEK
CLIFTON
CHIZRI SANITARIUM
OYSTER ROCKS
PIER
LAND
TRAINING WORKS
DEEP WATER POINT
No 2 Battery
MANORA POINT
Light House & No 1 Battery
BREAKWATER
ENTRANCE CHANNEL
CHURL CREEK
Scale
1000 0 5000 10000 15000 Feet

tect the outer part of the Manora anchorage so as to render it safely available during their prevalence.

At the shore end the top was to be raised to 4 feet above high-water of spring-tides, dropping to high-water at about one-third the way out, and so continuing to the end.

2. *Keamari groin and east pier.*—These two works, along the left bank of the entrance and harbor, are practically one, the east pier being actually the seaward continuation of the groin or jetty. This jetty runs in a slight curve, about south-south-east from the shore, for a length in the aggregate of about 9,050 feet.

It is a rip rap work, with its top generally 4 feet above high-water, except the outer end, 500 feet in length, which gradually slopes to the low-water level of spring-tides.

The object to be attained by this work was to concentrate and direct the tidal currents in the lower harbor and over the bar, and to stop the movement of sand over the east spit into the harbor from the eastward. This groin and pier on the east side, and Manora Point and breakwater on the west side, form two approximately parallel jetties, their least distance apart being a little over 2,000 feet.

3. *Chinna Creek stoppage.*—This is an embankment about 2,780 feet long and 15 feet wide on top, with side slopes of about 1 to 1, closing the mouth of Chinna Creek. This dam was designed to divert Chinna Creek and the east backwater generally into the harbor. For this purpose a portion of the northern part of Napier's Mole was cut away and replaced by an iron screw pile bridge.

A considerable amount of dredging was done in the new (western) entrance channel near Manora Point, and also at Deep Water Point, a projection on the west side of the lower harbor, consisting of sand and shingle, with underlying rock, disturbing the tidal currents, and causing eddies.

The works begun in 1861 were, in the main, finished in 1873, but they were not carried on continuously. Scarcely anything was done in the years from 1864 to 1869.

It is stated that the necessity for dredging was probably caused to a great extent by the fact that the works were not undertaken in proper order. The Manora Breakwater should have been built first, but was not, on account of its great expense.

RESULTS.

Without entering into details, it appears from the official reports that the scour caused by the Keamari groin or jetty, aided indirectly by dredging and excavations at Deep Water Point, and largely by dredging on the outer bar, has established a direct entrance channel 500 feet in width, 20 feet deep at low-water, and half a mile in length.

This channel is sheltered by the Manora breakwater.

Vessels of 22½ feet draught can now safely pass out or in during the southwest monsoons, and during the fair seasons 24 feet can be carried through. This is an increase of 5 to 7 feet during the monsoons, and 4½ to 6 feet during the fair season, as compared with the old directions.

The depth of water in the entrance channel is now 29 feet, at high-water of spring-tides, and 24 to 25 feet at high-water of neap tides.

The anchorage in the lower harbor has been deepened, enlarged, and stilled, though much of what was gained at Keamari up to 1869 has been temporarily lost through the deposit and accumulation of material scoured out from the new channel or upper harbor since the Chinna Creek stoppage was built.

In effecting these improvements it is estimated that up to January, 1878, over 2,600,000 cubic yards of material, mostly sand, was removed from the entrance and lower harbor, of which one-fourth was effected by dredging, and three-fourths by scour. From the upper harbor about 2,000,000 cubic yards were removed, one-third of which was effected by dredging, and the balance by scour.

The opinion is expressed by the engineer in charge of the works that these quantities have only half exhausted the capacity of the scouring works, though it will require several years, aided by dredging, with some additional works of no great cost, to develop their full effect.

The cost of all the works thus far executed is £490,940, or about $2,376,000.

It is stated that greater results might have been achieved at less aggregate cost if the works had been carried on in a different order and without stoppage.

Some of the works executed had, of course, no influence whatever in improving the entrance to the harbor, and were not designed for that object.

Among these may be named the native jetty and quay, which together cost about $200,000.

There seems to be a well-founded impression that the Chinna Creek stoppage has effected the lower harbor injuriously. The scour of the outflow of the eastern backwater has indeed deepened new channel, and thus given access to the "native jetty" for light craft; but the velocity of current is checked when it reaches the open harbor at Keamari, and the water drops the load of silt brought from above. It is estimated that the area of the valuable Keamari anchorage has been reduced 38 per cent. thereby.

Lately the question has been under consideration whether it would not be advisable to reopen the mouth of Chinna Creek.

It has been plainly suggested by some engineers that the Chinna Creek works should never have been undertaken, and that the works of improvement should have been confined to the lower harbor, with a view of transferring the center of business from Kurrachee to Keamari, as proposed by Sir Charles Napier, when governor of Sinde, in 1843.

Some additional work is now in progress. It consists (1) in dredging at the entrance, and in the lower harbor, and, also, at some places in the upper harbor; (2) in groining the west or right shore of the lower harbor, to aid the scour by reducing and regulating the width of its channel.

A project has been suggested, though not yet adopted, which contemplates (1) extending the Keamari jetty about 1,100 feet, in order to prevent eddies and shoaling in the entrance channel from the cross-rush of the flood currents, and (2) reducing the rocky projection at Deep Water Point, to lead the ebb currents into the entrance channel.

DETAILS OF CONSTRUCTION.

The Manora breakwater, commenced in 1859 and finished in 1863, consists of a base of rubble stone deposited from boats, and leveled off by helmet divers, generally to 15 feet below low-water, but near the shore to 10 feet below that level.

On this base concrete blocks, generally measuring 12 by 8 by 4½ feet each, and weighing 27 tons, were set on edge, without mortar, leaning back toward the shore end, at a slope of 3 inches to 1 foot.

The length of two blocks formed the width of the breakwater, and the width of three blocks its height above the base, the cross-section of the block wall being 24 by 24 feet.

At the shore end the top rises 4 feet above high-water of spring tides, dropping to high-water at about one-third the way out, and so continuing to the end.

The work has since settled, more or less, in the middle and outer portions as much as 2½ to 3½ feet.

It suffered some damage from the first few monsoons, some thirty blocks having been, at various times, washed out from the top course on the harbor side, which were replaced.

It now seems to be thoroughly consolidated, as the last four monsoons reported, to 1880, have done no damage.

The arrangement of the wall without bond greatly facilitated both execution and repair.

In fact, the success which has hitherto attended the completion of this breakwater is ascribed to the absence of horizontal and transverse bonds, as otherwise the structure, founded on a loose rubble base, would have been dislocated and ruptured by the unequal settling and yielding of the base, and by the force of the monsoon waves.

The seaward angle formed by the breakwater and the shore had to be strengthened by dumping in about 4,000 tons of rubble stone, and an equal amount was deposited as a "toe" on the seaward side of the superstructure. Including these quantities, the total amount of rubble stone consumed for the substructure appears to have been about 105,000 tons.

Each concrete block of 27 tons weight contained 432 cubic feet, and the following quantities of material intered into its composition:

English Portland cement, 9⅓ casks, or 3,729 pounds, or 44 cubic feet.

Sand from the bed of the Layarie River, 180 cubic feet.

Shingles from Manora conglomerate, 252 cubic feet.

Quarry lumps, Manora conglomerate, 144 cubic feet.

This is equal to one part cement to thirteen parts of other materials, exclusive of the sea water (about 432 gallons) used for incorporating the materials. The bulk of cement is one-tenth of that of the finished block.

The Keamari groin or jetty was commenced in November, 1861, and finished to the length of about 7,548 feet, as proposed by Mr. Walker, in April, 1863.

It is formed of rubble stone, tipped chiefly from wagons, but partly from boats. The size of stone varies from hand rubble to 4 or 5 tons, the larger stone being chiefly near the outer end.

The mean top width is 21 feet, with natural side slopes, and the top is 4 feet above high-water springs. Along each side is a bench to protect the toe. The bottom is sunk, more or less, into the sand; 177,591 tons of stone were used in this work.

The East pier, consisting of an extension 1,500 feet in length of the Keamari groin, was finished in May, 1865. It is similar in style to the groin, but owing to the greater exposure, larger stone was used generally in its construction. The last 500 feet of its length slopes off longitudinally from 4 feet above high-water to the level of low-water of spring tides.

This section is 20 feet wide at top, with side slopes as follows: From top level to

low-water datum, 1 upon 1½; from datum to bottom, 1 upon 2. There is also a bench on each side extending from the bottom of the slopes, 24 feet on each side, and 2½ feet in height.

This work contains 125,058 tons of stone.

Chinna Creek stoppage or dam, built from 1863 to 1874, is formed chiefly of rubble stone, with hearting and backing of stiff mud. The base extends a considerable width and depth, owing to the action of scour during the gradual contraction of the opening; but the dimensions cannot be exactly given, owing to the work being buried in sand.

In forming the bank, 65,328 tons of stone and about 42,000 cubic yards of mud backing were used, but the work having been spread over a period of about ten years was unavoidably expensive.

COST OF CERTAIN WORKS OF IMPROVEMENT.

The works comprised in Mr. Walker's plan were estimated to cost £300,000.
The following table shows the estimated amounts and the amounts actually used:

	Amounts estimated.	Amounts actual.
1. Manora breakwater	£110, 000	£69, 634
2. Keamari groin and east pier	82, 000	48, 317
3. Chinna Creek stoppage	9, 000	18, 827
4. Napier Mole screw pile bridge	40, 000	49, 012
5. Native jetty and quay	28, 000	43, 067
6. New channel	18, 000	62, 602
Total	287, 000	291, 459
Or, according to Mr. Walker, say	300, 000	291, 459

The actual cost of the works up to March 31, 1879, has been much higher, the additional expense being chargeable to dredging, plant and workshops, harbor surveys, and engineering superintendence.

The five years' suspension of work is reported to have added largely to the aggregate final cost of the improvement.

J 2.

IMPROVEMENT OF SULLIVAN'S ISLAND FOR THE PROTECTION OF CHARLESTON HARBOR, SOUTH CAROLINA.

By act approved June 14, 1880, the sum of $5,000 was appropriated for this work, and this is the first appropriation made by Congress for the special purpose named in the act.

This improvement was deemed necessary in order to prevent further encroachment by the sea upon the south shore of Sullivan's Island on that portion which lies from one-half to three-fourths of a mile east of Fort Moultrie, where considerable erosion had taken place during the two or three preceding years. The island is here very low, and forms but a narrow strip of land between the ocean and the large estuary in rear called "the Cove," and apprehension was felt that a severe south-east storm might cause a break clear through, endangering property and human lives.

Under date of August 3, 1880, proposals were invited for constructing one or more spur jetties at the place indicated, the same to be composed in part of one and in part of two layers of logs, placed close together, side by side, at right angles to the line of the work, firmly held by binders, and covered with riprap stone.

Whether the work was to be constructed with one or two layers of

logs, it was to be loaded with riprap stone to the amount of 1½ cubic yards of stone per linear foot of jetty.

Two proposals were received, and opened on August 31, 1880. One made by Mr. F. P. Murphy, of Washington, D. C., was found to be the lowest. The other bid was made by Messrs. Bangs & Dolby.

On August 7, 1880, a contract had been awarded to Mr. Murphy for delivering 20,000 cubic yards of stone upon the north jetty, Charleston Harbor. He was also an associate in contracts for works of improvement at the entrance to Cumberland Sound, Georgia and Florida, and at the mouth of Saint John's River, Florida, awarded on September 4, 1880.

Under these circumstances it was deemed best to wait and see what progress would be made by him in carrying out these more important contracts before making an agreement with him for building the Sullivan's Island jetty.

His progress under the stone contract was not satisfactory, and the bid made by Messrs. Bangs & Dolby being considered rather too high, the Chief of Engineers authorized, on November 2, 1880, a call to be made for new proposals by circular letter, which was done under date of November 4, 1880.

Only one bid was received, made by Mr. E. T. Bangs, of Fayetteville, N. Y. His offer was deemed satisfactory, and the contract for this work was awarded to him on November 18, 1880.

It had been the intention to construct two or three spur jetties placed from 700 to 1,000 feet apart, to be carried from the high-water line seaward, to lengths varying from 150 feet upwards, and at right angles to the shore line.

It was finally decided, however, to apply the remedy at the point most exposed, by constructing only one jetty. This point was about 3,100 feet east of Bowman's Jetty and about 2,500 feet west of the new north jetty. The work was constructed with great dispatch, being commenced December 15 and completed December 23, 1880.

The total length of the jetty is a little over 324 feet, of which length 162 linear feet are formed of a double layer of logs, and the balance of a single layer. The bottom width is 30 feet.

The total amount of riprap stone placed upon the jetty was 495 cubic yards.

The top of the jetty has a more gentle slope than the beach generally.

The construction of this work exhausted the appropriation made for it.

Cross-sections of both kinds of log-platforms, with riprap stone on them, as used for the Sullivan's Island jetty, are shown on sheet 1, accompanying this report. The location of the jetty is shown on the same sheet.

The jetty is in good condition, and begins to accumulate sand.

A recent survey has shown, however, that the shore of Sullivan's Island is still being rapidly eaten away in several places, and the necessity of further protection has become apparent.

This work is situated in the collection district of Charleston, at the port of entry.
Amount of import duties collected in 1880, $46,458.98.

The original estimate of cost of this work was about $6,000, as stated in my letter to the Chief of Engineers dated December 18, 1879.

Money statement.

July 1, 1880, amount available	$5,000 00
July 1, 1881, amount expended during fiscal year	5,000 00

Abstract of proposals for constructing jetties at Sullivan's Island, South Carolina, opened August 31, 1880.

No.	Bidders.	Per linear foot of jetty, 30 feet wide at base, covered with 1½ cubic yards of riprap stone.	
		For 1 layer of logs.	For 2 layers of logs.
1	Frank P. Murphy, Washington, D. C	$10 59	$19 18
2	Bangs & Dolby, Fayettville, N. Y	15 00	17 00

Proposals rejected and new ones invited under modified specifications.

Abstract of proposals for constructing jetties at Sullivan's Island, South Carolina, opened November 15, 1880.

No.	Bidders.	Per linear foot of jetty, 30 feet wide at base, covered with 1½ cubic yards of riprap stone.	
		For 1 layer of logs.	For 2 layers of logs.
1	Eli T. Bangs, Fayetteville, N. Y	$14 00	$15 50

Contract awarded at price stated. Work completed December 23, 1880.

J 3.

IMPROVEMENT OF ASHLEY RIVER, SOUTH CAROLINA.

The sum of $1,500 was appropriated for improving Ashley River, South Carolina, by act approved March 3, 1881.

An appropriation of $1,000 had been made for the same purpose by act approved June 14, 1880, which was the first ever made for the work.

A general description of the locality was given in my last annual report, contained in Appendix J 3, annual report of the Chief of Engineers for 1880.

No operations were carried on under the first appropriation. When the second appropriation was made, the shoals requiring improvement were resurveyed to fix the most suitable location, where the increased amount might be profitably expended.

On September 11, 1880, proposals were invited for dredging about 5,000 cubic yards of material in deepening Wando Shoal, about 9 miles above the city of Charleston.

If the limited means would allow, some dredging was to be done through the shoal at the lower entrance of Accabee.

No bids were received under this call, owing, probably, to the small amount to be expended. Efforts were made to do the work by hiring a dredge, but it was found to be impossible. The only dredges in the vicinity of Charleston suitable for the work are for the greater part of the year employed in dredging phosphates.

An aggregate sum of $2,500 having become available for the work, by

the additional appropriation, it is proposed to expend this increased amount during the present fiscal year, by dredging through a shoal about 2,000 feet below the old Wando works, where low-water depths of 7 feet exist, according to the recent survey, in order to connect the 11 feet low-water curves above and below.

It is the intention to do this work by contract, if practicable. If no offer deemed advantageous to the government shall be received, an attempt will be made to hire a dredge for the work.

There are two other shoals below the Wando, lower down, that are somewhat difficult, one of them in particular, requires greater width of channel. The cost of improving the river at these places is estimated at $2,500.

This improvement directly aids the business of the phosphate works located above the shoals referred to, and indirectly benefits the commerce of the city of Charleston.

The work is located in the collection district of Charleston, S. C. Charleston is the nearest port of entry.

Amount of duties collected in 1880, $46,458.98.

The report of Capt. B. D. Greene, Corps of Engineers, is appended.

Money statement.

July 1, 1880, amount available	$1,000 00	
Amount appropriated by act approved March 3, 1881	1,500 00	
		$2,500 00
July 1, 1881, amount expended during fiscal year		20 07
July 1, 1881, amount available		2,479 93
Amount (estimated) required for completion of existing project		2,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		2,500 00

REPORT OF CAPTAIN B. D. GREENE, CORPS OE ENGINEERS.

UNITED STATES ENGINEER OFFICE.
Charleston, S. C., July 12, 1881.

COLONEL: I have the honor to submit the following report upon the progress of the work of improvement of Ashley River, South Carolina, for the fiscal year ending June 30, 1881.

ASHLEY RIVER, SOUTH CAROLINA.

A survey of the bar known as the "Wando Crossing," just below the former site of the Wando Phosphate Works, was made in April last, and it was found that the improvement of this crossing by dredging would cost about $2,500. This amount is now available under the last two appropriations. The work will be done early in the fall. There are two other crossings below the Wando, that are somewhat difficult. One of them particularly needs increased width. The appropriation of the sum of $2,500 is asked for this last improvement.

Respectfully submitted.

BENJ. D. GREENE,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 4.

IMPROVEMENT OF WAPPOO CUT, SOUTH CAROLINA.

By the river and harbor act approved March 3, 1881, the sum of $10,000 was appropriated for improving Wappoo Cut, South Carolina, this being the first appropriation ever made by Congress for the work.

Wappoo Cut is a narrow, tortuous, tidal creek to the north of James Island, South Carolina, connecting Stono and Ashley Rivers.

An examination with a view to its improvement was made in October, 1880, in compliance with section 2, of the act approved June 14, 1880.

My report on this examination was submitted to the Chief of Engineers, with my letter dated November 22, 1880.

The project of improvement recommended, which contemplated the establishment of a straighter channel, of 6 feet depth, and 90 feet width at mean low-water, comprised the following details:

1. Dredging on the bar at the entrance into Ashley River.
2. A solid cut through the marsh at the end of the first easterly reach 2½ miles from Ashley River.
3. Dredging in Elliot's Cut, as well as in the reach leading to it, and on the bar at the outlet into Stono River.
4. Closing the three tidal streams that enter this new direct route from the north by bulkheads.
5. Building a jetty at the Ashley entrance to guide the flood-tide into Wappoo Cut.
6. Building a jetty at the Stono entrance to guide the ebb-tide into the cut.

The cost of this project was estimated at $34,000.

At present only 2 to 4 feet can be carried over the shoals at mean low-tide.

In a letter to the Chief of Engineers dated April 19, 1881, it was stated, that if it was thought desirable to expend this money during the ensuing fiscal year, work should be commenced at the Stono end of Wappoo Cut, the work to be done by contract, or by hiring a dredge, as might seem best.

It was suggested, however, that so little could be accomplished with the money appropriated, and the work done would be so wanting in permanency of character, that it might be best to wait until another appropriation was made.

The improvement of the navigation of Wappoo Cut is very desirable.

A considerable portion of the products of the Sea Islands, and adjacent country south of Charleston, is transported to that city through this cut, although difficult to navigate, in preference to taking the risks of the outward passage.

Sea-Island cotton, rice, and phosphate rock form the most valuable and the largest part of this traffic.

The aggregate value of commerce passing through last year was estimated at nearly $3,000,000.

All the productions of the district south of Charleston are reported to be yearly increasing. It is probable that a proper improvement of this tidal creek, will considerably aid the further development of agricultural industries interested in its navigation.

Some years before the civil war the State government of South Carolina made an appropriation for opening a straight cut, known as Elliot's

Cut, to connect one of the western bends of Wappoo Cut with Stono River. This cut is said to have been made 6 feet deep, and 90 feet wide, at low-water. It has shoaled up very much in consequence of being seldom used during the war, and since then, by being avoided by the steam-tugs, passing to and from the phosphate works, on the Stono, Coosa, and Bull rivers, and Charleston Harbor. These tugs prefer the old crooked channel, with its soft bottom, to Elliot's Cut, which is much harder, and consists principally of sand.

The work is located in the collection district of Charleston, S. C. Charleston is the nearest port of entry.

Amount of duties on imports collected in 1880, $46,458.98.

The report of Capt. B. D. Greene, Corps of Engineers, is appended:

Money statement.

Amount appropriated by act approved March 3, 1881	$10,000 00
July 1, 1881, amount available	10,000 00
Amount (estimated) required for completion of existing project	24,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	24,000 00

REPORT OF CAPTAIN B. D. GREENE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., July 12, 1881.

COLONEL: I have the honor to submit the following report, upon the progress of the work of improvement of Wappoo Cut, South Carolina, for the fiscal year ending June 30, 1881.

WAPPOO CUT.

An examination of this cut in March, showed that the amount appropriated by the river and harbor act for the current year, for the improvement of Wappoo Cut, was not sufficient to begin the work with, unless at a great disadvantage. This is one of those cases of opening a new channel, and closing the old one, in which it is desirable to have money enough to carry the work well on to completion when it is once begun. For this reason the appropriation of $24,000, the balance of the estimated cost, is asked for the coming year.

The importance of this work is indicated in your report of last year.

The business carried on by way of this cut is annually increasing, and the expenditure of a small amount of money will benefit the general commerce of this section.

Respectfully submitted.

BENJ. D. GREENE,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

EXAMINATION FOR THE IMPROVEMENT OF WAPPOO CUT, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, November 22, 1880.

GENERAL: I have the honor to submit the following report of an examination of "Wappo Cut," South Carolina, with estimates of the cost of works of improvement, as provided for by section 2 of the river and harbor act approved June 14, 1880, and assigned to my charge by letter of June 17, 1880.

The examination was made by Capt. J. C. Post, Corps of Engineers,

my assistant at Charleston, S. C. His report with accompanying sketch is herewith inclosed.

Wappoo Cut is a narrow, tortuous, tidal stream, to the north of James Island, connecting Ashley and Stono rivers.

The mean rise and fall of tides in Wappoo Cut is about 5 feet. The general direction of the stream is east and west, and it forms an important link in the inland water-route connecting Charleston Harbor with a considerable area of the coast district south of that city.

The length of the Wappoo Cut route, as generally used, is about $5\frac{1}{4}$ miles. It varies in width from 60 feet to 200 feet, and in low-water depth from 1 foot to 13 feet, the shoalest water being found in its westerly reaches.

Captain Post's report shows Wappoo Cut to be of considerable importance as a commercial route. During the past year the aggregate value f freight of all kinds passing through amounted to nearly $3,000,000. he bulk of it consisted of sea-island cotton, rice, and phosphate fertilers. It is stated that this trade is annually increasing, and that it would be still more rapidly developed by a suitable improvement of the passage.

The plan of improvement suggested by Captain Post, which contemplates the creation of a channel of 6 feet minimum depth and 90 feet width at mean low-water is approved. It comprises the following details of work:

1. Dredging on bar at the entrance into Ashley River.
2. A solid cut through the marsh at the end of the first easterly reach, $2\frac{1}{2}$ miles from Ashley River.
3. Dredging in Elliott's Cut, as well as in the reach leading to it, and on the bar at the outlet into Stono River.
4. Closing the three tidal streams that enter this new direct route from the north by light bulkheads.
5. Building a jetty at the Ashley entrance, to guide the flood-tide into Wappoo Cut, and
6. Building a jetty at the Stono entrance, to guide the ebb-tide into the cut.

From the fact that high and low water occur about an hour later at the Stono terminus of the passage than at the Ashley entrance, currents run through the cut in a westerly direction during a greater part of the flood-tide, and in the opposite direction during a great part of the ebb-tide. These favorable conditions will be not only preserved, but probably strengthened, by straightening and deepening the passage. In that case, there would practically be no intermediate place where the tides would "meet" or "divide," and one of the principal causes for shoaling would disappear.

It is possible that after carrying out the works here recommended it may be found desirable to straighten the passage still more, by a cut to avoid the first great bend situated about $1\frac{1}{2}$ miles from Ashley River, but since this bend has sufficient depths and widths, it is not considered as offering serious obstructions to navigation. As the value of such a cut would consist chiefly in still more shortening and straightening the passage, its execution may be held in abeyance for the present.

This improvement is located in the collection district of Charleston. Charleston is the nearest port of entry.

The amount of duties on imports collected in the year 1879 was $24,070.

For further particulars concerning this route, I beg leave to call attention to Captain Post's report.

The estimated cost of the improvement, including ten per cent. for contingencies, is about $34,000.

There has been no previous appropriation made by the government for the work.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers,
Brt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER'S OFFICE,
Charleston, S. C., November 15, 1880.

COLONEL: In compliance with the instructions contained in your letter of August 2, 1880, I have to submit the following report of the examination of Wappoo Cut, S. C., together with a plan and estimate for its improvement.

Wappoo Cut or Creek is a narrow, tortuous, tidal stream connecting the Ashley and the Stono rivers, and forms a portion of the only inland route for navigation between Charleston Harbor and the country south of it. It intersects the Ashley River opposite the city of Charleston, about 6 miles from the outer harbor, and joins the Stono River about 13 miles from its mouth. Its length by the channel now principally used, as indicated by the dotted black line (see inclosed sketch), is 5¼ miles, and its width varies from 200 feet in the first 3½ miles from the Ashley River, which is nearly uniform, to 60 feet at its junction with the Stono River, where it has the least width. Passing from the Ashley River, the first 2½ miles, which is comparatively straight, contains not less than 8 feet of water at low-water, with the exception of the bar at its mouth. This latter had formerly only 2 feet of water upon it at low-water, but since the creek has become of such importance the frequent passage of steam-tugs has increased the depth to 4 feet at low-water. At the extremity of 2½ miles there is a shoal upon which there is but 4 feet of water at low-water. Beyond this the creek takes an exceedingly tortuous course through the marshes, and is nearly three miles in length before it meets the waters of the Stono River, while in a straight line the distance is less than a mile. The depth in this portion varies from 1 foot to 13 feet at low-water.

A number of years ago, before the late war, the increasing importance of this creek and the difficulties encountered in navigating the last two miles and in crossing the bar at the Stono entrance, induced the State of South Carolina to make an appropriation for opening a straight cut about 1,500 feet long, now called Elliot's Cut (see sketch), connecting one of the principal bends of the creek with the Stono River. This cut, which I am informed was made 6 feet deep at low-water, and about 90 feet in width, reduced the distance from the Ashley to the Stono River about a mile. At the time the cut was made the reach passing into it from the eastward was 125 feet wide and from 7 feet to 20 feet deep at low-water. The cut and reach have since shoaled, until now there is but from 2 feet to 4½ feet at low-water through them, and a bar has formed at the Stono entrance of the cut, over which there is scarcely a foot of water at low-water. These changes took place largely during the war, when this creek was seldom used, and have been added to since by the increased depth in the old channel caused by the frequent passage of steam-tugs to and from the phosphate works on the Stono, Coosa, and Bull rivers, to Charleston Harbor. These tugs preferred the old channel with its sharp bends and greater length, where the bottom was soft and could be easily cut out by their wheels, to Elliot's Cut and its firmer deposit, which is composed principally of sand.

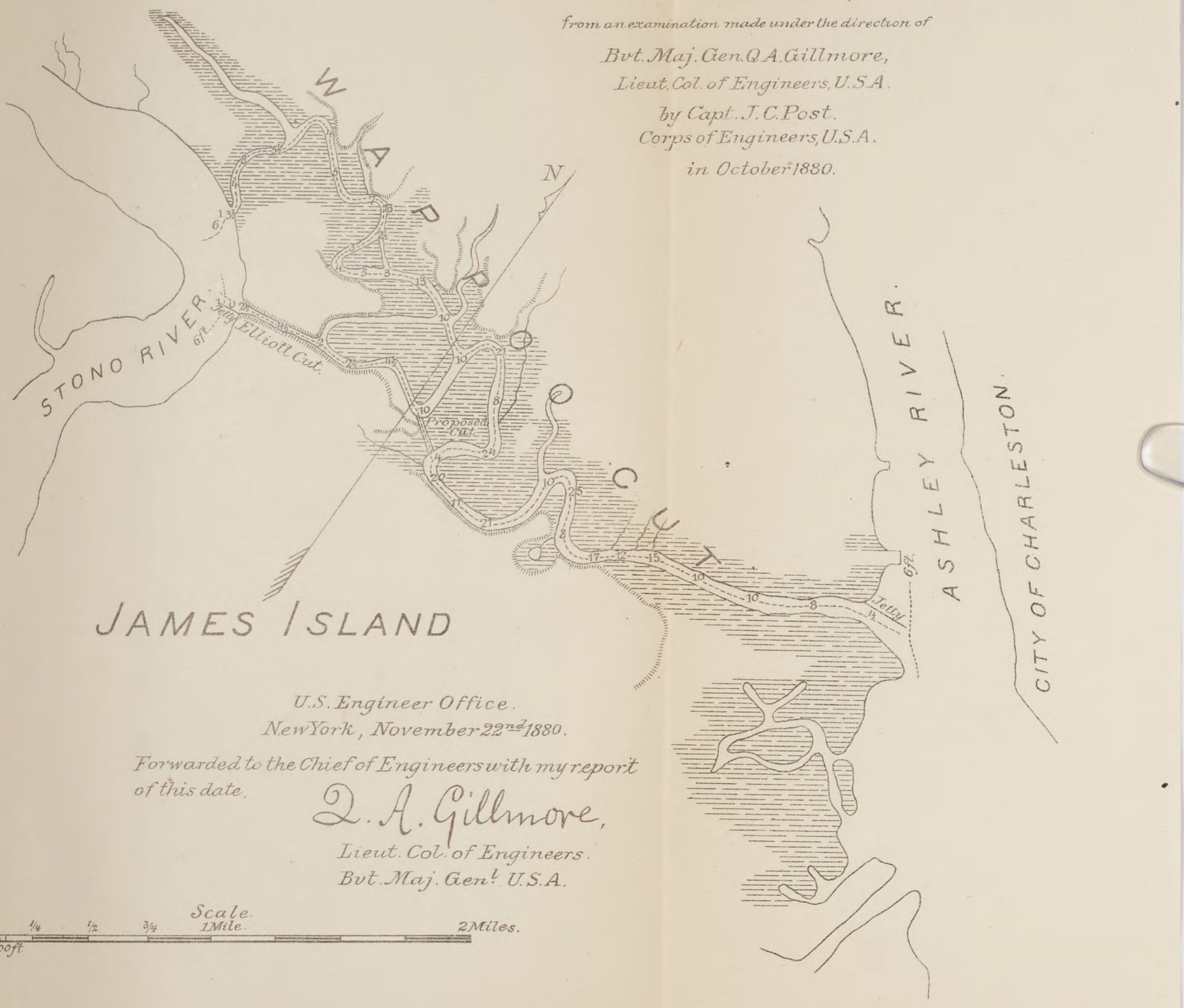
The great importance of this creek can readily be seen from the amount of commerce passing through it yearly. By reliable persons this was estimated to have amounted to about $2,800,000 during the past year, and comprised as follows, viz:

7,000 bags sea-island cotton, at $120 each	$840,000 00
400,000 bushels of rice, at $1.50 each	600,000 00
80,000 tons phosphate rock, at $7	560,000 00
Naval stores	100,000 00
Vegetables and truck farming	100,000 00
General traffic	600,000 00
	2,800,000 00

SKETCH
of
WAPPOO CUT, S.C.

from an examination made under the direction of

Bvt. Maj. Gen. Q.A. Gillmore,
Lieut. Col. of Engineers, U.S.A.
by Capt. J.C. Post.
Corps of Engineers, U.S.A.
in October 1880.



U.S. Engineer Office.
New York, November 22nd 1880.

Forwarded to the Chief of Engineers with my report of this date.

Q. A. Gillmore,
Lieut. Col. of Engineers.
Bvt. Maj. Gen.l U.S.A.

Scale.
0 1/4 1/2 3/4 *1 Mile.* *2 Miles.*
0 500ft

All of these productions of the country south of Charleston are increasing yearly, notwithstanding the difficulties of navigating this creek tend to retard their development by forcing a portion of the commerce to reach Charleston by taking the risks of the open sea. It is not improbable that the proper improvement of this creek will at once increase the amount of the commerce passing through it very considerably above the foregoing estimate.

PLAN OF IMPROVEMENT.

To make a channel 90 feet wide and 6 feet deep at low-water from the deep water of the Ashley to that of the Stono River, which I am informed will be ample for all steamers passing through this creek, I would respectfully suggest that the bar at the Ashley entrance be dredged, that a straight cut be made through the marsh, from the bend at the extremity of the 2½ miles before mentioned, to connect with the reach opening into Elliot's Cut, and that this reach, Elliot's Cut, and the bar at its mouth be dredged. This will reduce the distance from the Ashley to the Stono River to 3¼ miles. It will also be necessary to cut off all the streams emptying into this direct channel from its north side to prevent the possibility of the formation of shoals at the junction. The results of the tidal observations which have been taken at the extremities of the present channel show that the tide at the Stono end of the creek is about an hour later than that at the Ashley, and that both the flood and the ebb tides during three-fourths of their flow pass entirely through the creek from the Ashley to the Stono River, and *vice versa*. By reducing the length of the channel, as proposed, it is expected that nearly the whole if not all of these tides will flow entirely through the creek from the Ashley to the Stono River and return, without there being a place of meeting of the waters from the two rivers on the flood or division on the ebb anywhere in the creek. It seems fair to assume that this will be the case, as the distance from the junction of the creek with the Stono, which is 13 miles from the sea by the Stono, will be but 9¼ miles from the sea by the creek and the Ashley, and the creek will be comparatively free from bends to retard the tidal flow.

Should this take place, as appears probable, I do not apprehend that there will be any difficulty experienced in keeping the two bars open at the extremities of the new channel after they are once dredged. As it is possible, however, that some aid may be required to keep these bars from reforming, I have added to the estimate, to make the plan complete, the cost of constructing two jetties, composed of wood and stone, one to be placed at each bar. That at the Ashley should be located, as shown on the sketch, to narrow the channel across the bar and deflect the flood tide into the creek. It should average 20 feet wide at the base and extend from the shore to the 6-foot curve, a distance of 1,000 feet. The one at Stono should be located, as shown on the sketch, to narrow the entrance across the bar and deflect the ebb tide into the creek. It should also average 20 feet wide at the base and extend to the 6-foot curve, a distance of 600 feet. The total estimate for the dredging is 100,000 cubic yards, 10,000 cubic yards to be removed from the Ashley Bar, 30,000 cubic yards from the Straight Cut, 800 feet long through the marsh, 35,000 cubic yards to be removed from the reach joining Elliot's Cut, and 25,000 cubic yards from Elliot's Cut and the bar at its Stono extremity. To close the three streams entering into the new channel from the north, it is proposed to make a slight structure of piles and boards, one that is sufficiently strong and will last long enough to keep the dredging in place, which should be dumped in rear of it, until they harden.

The total length of this bulkhead will be 700 feet.

The following is the estimate of the cost of these improvements, viz:

100,000 cubic yards of dredging, at 18 cents per cubic yard	$18,000 00
1,600 feet of jetty, at $7.50 per linear foot	12,000 00
700 feet of bulkhead, at $1.50 per linear foot	1,050 00
Contingencies, 10 per cent	3,105 00
Total	34,155 00

The jetties should be raised to the line of average high-water.

The average rise and fall of the tide in the creek is 5 feet.

This improvement is located in the collection district of Charleston. Charleston is the nearest port of entry.

Very respectfully, your obedient servant,

J. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 5.

IMPROVEMENT OF SAVANNAH RIVER AND HARBOR, GEORGIA.

During the last fiscal year the operations for the improvement of Savannah River and harbor were carried on in conformity to the general plan submitted August 28, 1873, and the supplementary project of March 19, 1879.

During the two years preceding the autumn of 1873, Congress had appropriated the sum of $100,000 for improving the river below the city of Savannah, which has been expended mainly in removing wrecks, cribs and other obstructions.

No money had been appropriated before this since the close of the civil war.

By act approved February 27, 1874, Mr. Henry S. Wells was paid the sum of $193,132.96 for expenditures made by him under contracts with the Treasury Department of May 1, and July 5, 1866, for removing obstructions from the Savannah River. This work comprised the removal of twenty vessels, forty cribs, one hundred and fifty piles, many iron-shod snags, and a number of torpedoes.

By the project of August 28, 1873, it was designed to provide for an improved channel from Tybee Roads to the city of Savannah, navigable at high-tide for vessels drawing 22 feet of water, where previously the navigable high-water depth rarely exceeded 16 feet.

The entire cost of the project, omitting bank protections and jetties or wing-dams, was estimated at $481,320. Since its adoption there has been appropriated, to June 30, 1881, the sum of $482,000. The expenditures during the same period, and including outstanding liabilities, were $311,528.22.

The supplementary project of March 19, 1879, had for its principal object the improvement of the north channel of the Savannah River in preference to the south channel, from the head of Elba Island to the head of Long Island. This object was to be obtained by closing the openings between the island by means of dams, and contracting the area of cross-section of the south channel, to secure a larger volume of flow in the north channel.

It was estimated that the construction of these various dams up to the level of ordinary low-water, the enlargement of the ship-channel by dredging to a minimum depth of 14½ feet and a width of 125 feet at mean low-tide in all the shoals between the city of Savannah and Tybee Roads, and the requisite deepening of the channel above the city to aid the flow of the ebb and flood currents, would add only a small amount to the estimate of August 28, 1873.

Since it has been decided to build the dams between the islands up to high-water level, the original estimate of $481,869.64, for works thus far approved, will probably be exceeded by from $25,000 to $30,000.

The necessary details concerning the project so far as it has been adopted were furnished in my annual report for the year ending June 30, 1881, accompanied by the supplementary plan for further improvement of Savannah River and Harbor, dated March 19, 1879, contained in Appendix J 4, Annual Report of the Chief of Engineers for 1880, to which attention is herewith invited. It was remarked in the report that other works would be needed in addition to those named above, and not yet estimated for. The river below the city is excessively wide at some points, and suitable works of contraction will be necessary to in-

sure the permanent maintenance of the channel contemplated to the required depth.

In regard to the question of the amount of commerce and navigation that may be benefited by completing these works of improvement, some statistics and other information have been received from Hon. J. F. Wheaton, mayor of the city of Savannah; from the collector of customs at that port, and from other trustworthy sources. The data thus obtained will be stated in condensed form.

There seems to be no doubt that there has been at Savannah a decided increase of business during the last four years, each year showing an excess over the preceding year. This fact is plainly demonstrated by Table A, appended to this report, and furnished by the mayor of the city.

Savannah has long been known as an important place for shipping cotton. For the year ending August 31, 1881, the number of bales received and shipped is estimated at 900,000, which is probably near the truth, since it was known that up to May 24, 1881, not less than 848,980 bales had been received during the preceding nine months. This represents about one-sixth of the entire cotton crop of the United States, and exceeds by about 50 per cent. the amount received during the same length of time four years ago.

In naval stores the receipts were comparatively still larger.

The custom duties of last year were $78,458.41, exceeding those of any previous year. (See table B.)

The tonnage of the port has likewise increased during the last three years in the number as well as the capacity of vessels employed. In the fall of 1880, sixteen large Clyde-built iron steamers were seen loading at the same time, at the cotton-press wharves of the city; none of them, it was stated, would carry less than 5,000 bales of cotton. They usually load down to about 19 feet draught, when they are careened to one side, and towed to Venus Point, about 9 miles below the city, to finish their cargoes.

It is expected that a daily line of steamers to New York will soon be established, and that within two years a regular line of steamers will ply between Savannah and Liverpool, or some other British port.

The city is well furnished with railroad connections with the interior of the State of Georgia, and with adjacent States.

Two important railroad lines terminate at Savannah, viz, the Savannah, Florida and Western Railroad, and the Central Railroad of Georgia.

The Charleston and Savannah Railroad is not considered to be of great value to the city for shipping purposes.

The Port Royal and Augusta Railroad, intersecting the Charleston and Savannah road at Yemassee and connecting at Augusta with the Central Railroad of Georgia, has been leased by the latter.

The Savannah, Florida and Western Railroad, from Bainbridge to Savannah, with its connections with the Macon and Brunswick and the Brunswick and Albany railroads and by branches from Thomasville to Albany and from Dupont, Ga., to Live Oak, Fla., is well located to drain the southern and southwestern counties of Georgia, and adjacent counties of Alabama and Florida.

The Central Railroad of Georgia is the most important line, a large portion of the central and northerly counties of Georgia being naturally tributary to it.

The main line from Savannah to Atlanta with its numerous ramifications is not only well designed to transport the surplus produce of the State and adjoining districts to Savannah, and to supply them in return

with goods from that port, but it is quite as well adapted, in connection with other roads north of Chattanooga to form through freight lines to the great grain-growing States of the Mississippi Valley.

With the present railroad facilities all the territory lying south of an imaginary line drawn from Savannah to Cincinnati and from Cincinnati to Saint Louis, together with the vast grain-growing region west of Saint Louis is as legitimately tributary to Savannah as to any other Atlantic port, as shown by the following table of distances:

Statement of mileages from Savannah, Ga., to western points.

Louisville, Ky.		Cincinnati, Ohio.		Saint Louis, Mo.		Chicago, Ill.	
Roads.	Miles.	Roads.	Miles.	Roads.	Miles.	Roads.	Miles.
Central	295	Central	295	Central	295	Central	295
Western and Atlantic.	138	Western and Atlantic.	138	Western and Atlantic.	138	Western and Atlantic.	138
Nashville, Chattanooga, and Saint Louis.	151	Cincinnati and Southern.	336	Nashville, Chattanooga, Saint Louis, Chattanooga Division.	151	Nashville, Chattanooga, and Saint Louis.	151
Louisville and Nashville.	185			....do	181	Evansville and Terre Haute.	155
				Saint Louis Division, Saint Louis and Iron Mountain.	215	Chicago and East Illinois.	178
Total	769	Total	769	Total	980	Total	1,026

Mileages from New York, via Pennsylvania Railroad, to—

	Miles.
Louisville, Ky	867
Cincinnati, Ohio	757
Saint Louis, Mo	1,065
Chicago, Ill	912

It is seen that Savannah is materially nearer than New York to Louisville and Saint Louis, while the distances of the two places from Cincinnati are practically the same. It is therefore reasonable to expect that the rates from the West to Savannah should be about as low as to Baltimore, Philadelphia, and New York, and that with good terminal facilities, the rail lines leading to that city would share in due proportion with the northern through lines, the export business of the West and Northwest.

When the western crops are to be moved the northern trunk lines are frequently overburdened. The Western States are rapidly growing in population and in the development of their agricultural and other resources. Both producer and merchant are looking for other routes to avoid the delays resulting from the excessive transportation business thrown upon the existing through lines.

The importance of this through traffic is fully recognized by the managers of the Georgia railroads and their connections, and they are now prepared to make as low rates for bringing western products to the Atlantic coast, as those charged by the northern trunk lines.

Hitherto the shipments of grain, tobacco, and flour to this port have been very light, since no facilities were offered for handling grain in bulk, and because neither merchants nor railroad companies had made serious efforts to secure the export business. They are now turning their attention to this important matter. The Central Railroad and

Banking Company of Georgia is now building a grain elevator in Savannah to induce shipments of grain through this place.

All these recent efforts to attract new and important business to the city cannot be entirely successful unless a navigable channel of sufficient depth is furnished for the whole length of the river, from Tybee Roads to the city of Savannah. The present project contemplates creating and maintaining a channel navigable at high-tide for vessels drawing 22 feet of water. Before such depth can be secured, it is certain that the requisite works for contracting the channel, referred to in previous reports, will have to be constructed. An approximate estimate of the cost of these works is submitted at the close of this report.

It may be mentioned that even now leading business men in Savannah are asking for a navigable river channel of 22 feet depth at low-water, and for a harbor width of 800 feet at the city. It is obvious that while a project involving such dimensions is practicable, its execution would require considerably more time, and the expenditure of much larger sums of money than the present project contemplates.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

The progress by contract work during the fiscal year just closed has been slow and unsatisfactory, except in the matter of dredging. The method recently authorized by the Chief of Engineers, for carrying on the work of improvement, especially below the city, by hired labor, is now being inaugurated, and when perfected is expected to secure substantial work and rapid progress.

1. *The cross-tides dam.*—The cross-tides dam, built by contract, was commenced in December, 1878, and on June 30, 1880, still required 245 cubic yards of riprap stone to finish its superstructure according to the terms of the contract.

The work was completed in November, 1880.

The mode of construction has been described, with the necessary details in my annual reports for the years 1879 and 1880.

The dam extends in a straight line from the nearest rice dike on Hutchinson's Island across the river to the nearest dike on Argyle Island. Its length between the low-water lines of the river is about 780 feet; its aggregate length, including both shore ends, nearly 1,000 feet.

After its completion the top of the dam at many points reached up to about the level of ordinary low-water, in some places even above it; but in the deep water channel near Argyle Island there is from 6 to 8 feet depth of water at low-tide above the crest of the superstructure for a width of about 100 feet.

Some complaints have been made during the past year by planters on the upper end of Hutchinson's Island that the tides are now higher below the dam in Back River than they formerly were, and that in consequence they are compelled to raise their dikes. From reports of the assistant engineer it appears that the occurrence of unusually high-tides caused the greater high-water level complained of.

With anything like a freshet the water rushes over the dam like a rapid. The adjacent dikes on Argyle Island seem to be amply strong and secure as long as the erosion of the shore in front is prevented, but those on Hutchinson's Island seem to be weak and liable to be injured by storm tides.

The changes in the river-bed in the vicinity of the dam are somewhat marked. Below the dam the depths have been greatly increased by the scour of the ebb currents for a considerable distance. There was, for

instance, an average depth of 8 feet and a maximum depth of 16 feet at low-tide on a line 60 feet below the site of the dam, according to the Coast Survey chart of 1874; in May last the average depth on the same line amounted to 15 feet, with a maximum depth of 36.5 feet.

The width of the channel between the 12-foot curves, for some distance above and below the dam, was formerly about 180 feet, and the pocket formed by that curve ended about 1,000 feet above the site of the dam, near the Argyle Island shore. This channel has widened to 240 feet above the dam and extends about 600 feet higher up than formerly. Below, it has expanded excessively, approaching the low-water line on both shores, more especially on Argyle Island side. The greatest depth found in this portion of the river at the survey made under my direction in the early part of 1873 was 20 feet at low-water at one point only; now, on a line about 100 feet below the dam, the width between the 18-foot curves is about 350 feet, with depths amounting at many points to 38 and 39 feet at low-tide.

Eddies are produced by the currents after crossing the dam, scooping out the river-bed and impinging upon the shore of Argyle Island. It was deemed probable that continued erosion would endanger the rice dikes near by, and that precautionary measures should be taken. The shore was therefore protected by means of brush mattresses, 1 foot thick after compression, 26 feet wide, covering an aggregate length of 155 feet of shore line, beginning at the dam. It was covered with riprap stone to an average thickness of 6 inches, and was completed on June 2, 1881.

On the area of the river comprised between the old King's Island jetty and the new dam depths have generally somewhat increased, but in the triangular space on the up-stream side of the southerly or Hutchinson's Island portion of the dam some shoaling seems to be progressing. The deep-water pocket caused by the scour around the end of the old jetty has increased in area and depths since the surveys of 1873 and 1874, and the south channel between King's Island and the mainland has considerably deepened.

A further raising of the dam was recently decided upon, partly to reduce to some extent the large volume of water still flowing over it to Back River, and partly for the better protection of the shores of Argyle Island.

2. *Deepening of Front River between the cross-tides and the city of Savannah.*—The cut made during the preceding fiscal year through the old King's Island jetty was widened from 35 feet to about 70 feet to facilitate the flow of water from the cross-tides towards Front River It may become advisable to remove still more of this work.

Some dredging was done in the channel between King's and Hutchinson's islands to aid the flow into Front River. The total amount of material dredged here during the past fiscal year was 24,849 cubic yards.

A marked improvement in the South Channel, between King's Island and the Georgia shore, has taken place. A widening of the river, at the upper end of the channel especially, seems to be desirable for the admission of the greater flow of water that is expected from the effects of the increased height to which the crest of the Cross Tides Dam is to be raised. By comparing the chart of the survey of May, 1881, with that of 1874, it appears that the 6-foot low-water curve is now nearer to the main shore than formerly, and it may happen that when the volume of water passing through this channel shall have been materially increased, an objectionable erosion of the banks will ensue, which may be prevented by cutting off a portion of the King's Island shore.

Assistant Engineer S. L. Fremont reports that all the way from King's

Island to the deep water at the wharves of the Central Railroad of Georgia, a distance of 3 miles, the channel has increased in depth and width.

3. *Enlargement of the water-way in front of the city of Savannah.*—Under the existing project the minimum width of the river to be established in front of the city wharves will be about 600 feet, enlarged to 650 feet at Fig Island, in front of the wharves of the Savannah, Florida and Western Railroad. The depths of this portion of the river it is desired to make sufficient to enable vessels drawing 22 feet of water to be moved from wharf to wharf at any stage of the tide.

For the purpose of widening the streams as indicated, strips of land have to be cut off from the opposite shores of Fig Island and Hutchinson's Island.

The title to strip to be cut from Fig Island, amounting to about $3\frac{1}{3}$ acres, was not perfected until the beginning of the present year; the removal of land by dredging was commenced in February, and was continued until June. The material here removed in that time amounted to 118,229 cubic yards. All the land condemned has been cut away, the water-way widened more than 150 feet, with a 10-foot low-water channel close by the shore.

By act of Congress approved March 3, 1881, the sum of $65,000 was appropriated for improving Savannah Harbor and River, of which sum $1,000 may be applied to payment of damages for land taken for widening the river.

Estimates for damages at Hutchinson's Island, opposite the upper part of the city, have not yet been made by the commissioners appointed for the purpose. It is understood that the owners of property are to be supplied by the city with a quantity of land equal to that cut off, which leaves the actual damages to be paid to depend upon the cost of removing and rebuilding the mills, wharves, and other structures now located on the land to be condemned. It may be expected that the cost of securing the land on Hutchinson's Island will greatly exceed that of the land obtained at Fig Island.

Some dredging was done at Garden Bank for the accommodation of vessels approaching the city wharves from below. The total amount of material here removed during the year was 18,813 cubic yards. The channel across this shoal has been widened 75 feet, giving with the dredging done during the preceding year a channel width of 150 feet and a low-water depth of 16 feet.

The amount of material that must be removed from Hutchinson's Island to secure a width of 600 feet is estimated by Assistant Engineer Fremont (Report June 21) at about 120,000 cubic yards. The total length of shore line along which cutting will be required is about 2,500 feet; the average width of the strip 65 feet, and the average depth of cutting 20 feet.

In addition to this the river bed has to be considerably lowered to permit vessels drawing 22 feet to be moved about in the harbor at any stage of tide. Mr. Fremont estimated the volume of material to be thus taken off at about 500,000 cubic yards.

The aggregate amount of material still to be removed for suitable widening and deepening the harbor of Savannah appears therefore to be not less than about 600,000 cubic yards. It is not supposed that all this material must be taken off by dredging; it is expected that the scouring effects of the increased currents will perform a part of the work.

4. *The new channel at "The Wrecks."*—During the first quarter of the past fiscal year the United States dredge-steamer Henry Burden removed

from this channel 12,019 cubic yards of material. This channel has generally maintained its full low-water depth of about 13 feet, with the exception of a small shoal formed at the mouth of a creek by deposits of sand and mud brought from the rice fields, and which requires periodical dredging until a larger volume of water can be forced through this channel.

Opposite the lower end of Fig Island, where Front River enters this new channel, it had been observed that a projecting portion of the mainland, known as Screven's Point, deflected the ebb-currents across to the great shoal of "The Wrecks," causing great inconvenience and danger to vessels. Cases of grounding on that shoal are not infrequent. The Savannah, Florida, and Western Railroad Company having recently increased their frontage on the river, with the intention of extending their present wharf a considerable distance down stream, a bulkhead line was fixed defining the future wharf line and cutting off Screven's Point to a length of about 800 feet and a width of about 100 feet at the widest point.

The reduction of Screven's Point was commenced in the latter part of the past fiscal year; the aggregate amount of material here removed was 32,505 cubic yards. The result has been satisfactory. The removal of about 5,000 cubic yards more will complete the work.

The necessity for building a training-wall, or some other suitable work extending from the lower end of either Hutchinson's or Fig Island down stream, has lately become more apparent. Such a work will, it is thought, effectually protect the channel at "The Wrecks" and promote its gradual deepening through scour by preventing the silt brought in from Back River by strong northeast winds from being deposited in the channel.

5, 6, 7, *and* 8. *Dams between the Islands and in South Channel.*—As stated in my previous annual report, a contract for building these several dams was made on November 15, 1879, with Mr. R. C. McKay, of Philadelphia. The works comprised a submerged dam across the upper end of the South Channel, head of Elba Island, and three closing dams across the openings between the islands, from Elba to Long Island.

Up to June 30, 1880, about 425 linear feet of the bottom course of the South Channel dam, and some work on the shore ends, had been partially completed.

During the past fiscal year the bottom course of mattresses for this dam was completed. The aggregate length of this apron is about 1,460 feet. The mats vary from 16 to 24 feet in width; they are 1½ feet thick, and are covered with stone to a thickness of about 6 inches. The shore end of the Elba Island side has a length of about 50 feet from low-water to high-water; the corresponding length on the Georgia shore is over 400 feet.

About 394 linear feet of the apron or bottom course are covered with a second course of mats. These are 14 feet wide for a length of 323 feet, and 10 feet wide for a length of 71 feet. Of the portion 14 feet wide a length of 266 linear feet was covered with a third course of mats of 10 feet width, all covered with the requisite amount of stone. It is estimated that about 560 linear feet of the upper courses will finish this dam so far as contemplated in the contract. Under the present project it is proposed to keep the South Channel dam submerged, but it may have to be raised somewhat higher than originally contemplated.

No other work was done under the McKay contract during the last fiscal year, with the exception that some piles were driven for the proposed dam at Philbrick's Cut.

In July, 1880, the sureties of Mr. R. C. McKay were informed that the

latter had failed to do the work according to his agreement, and were asked whether they were prepared to carry it on themselves; otherwise the contract would be annulled. By request of Mr. Nathaniel McKay, one of the sureties, and with the approval of the Chief of Engineers, the contractor was allowed to give a power of attorney to Mr. R. G. Ross, of Wilmington, N. C., to proceed with the work. This arrangement was made in August, 1880, but operations under it were not resumed before December following. They were then carried on so slowly that the contract was finally annulled under authority of the department, dated May 19, 1881. Preparations are now in progress to do this work by hired labor, purchasing the materials in open market.

9. *Shore protections.*—Nothing was done during the past fiscal year for the purpose of protecting the shores.

10. *Dredging below the head of Elba Island.*—The channel at the obstructions at the head of Elba Island has at present a navigable low-water depth of 13 to 14 feet. Some works may have to be constructed to concentrate scouring currents upon this shoal to maintain such suitable depths as may be obtained here through dredging or otherwise.

The United States dredge-steamer Henry Burden removed from the shoal during the past year 13,276 cubic yards. The same steamer did some work in the North Channel during September and October, 1880, removing about 10,350 cubic yards from the "Upper" and "Lower Flats," opposite the central part and lower end of Elba Island, respectively.

During the last winter the Henry Burden was put to work in the channel at Tybee Knoll, northeast of Fort Pulaski. About 26,000 cubic yards of material were here taken out, increasing the low-water depth of the ship channel from 12 feet to 14 feet.

A troublesome lump and remnant of wrecks exist in the channel opposite Oyster Bed light, northwest of Fort Pulaski. The American Dredging Company was lately directed to improved this passage by dredging. About three years ago some dredging was done at this point, resulting in the establishment of a channel 120 feet wide and 14 feet deep at mean low-water. It is expected that from 30,000 to 40,000 cubic yards of material must be here removed, a work which has been recently commenced.

SUMMARY OF WORK DONE DURING THE PAST FISCAL YEAR.

The submerged dam at the Cross Tides was completed in conformity to the original design by adding 245 cubic yards of stone to the superstructure, the shore ends repaired, and the adjacent shore of Argyle Island protected from erosion.

The gap through the Old King's Island jetty was enlarged to 70 feet. Work on the submerged dam across the South Channel was continued for some time. When work shall be resumed under a new arrangement, it is expected that the dam can be finished in eight or ten days.

Dredging has been executed at various places from the Cross Tides down to near Tybee Roads.

The total amount of material dredged was, according to Assistant Engineer S. L. Fremont's appended report, 268,220 cubic yards, of which 59,461 yards were taken out by the United States dredge-steamer Henry Burden, and the balance by the American Dredging Company of Philadelphia, under two contracts made with them, one on December 16, 1878, at the price of $14\frac{3}{8}$ cents per cubic yard, and the other on October 20,

1880, at 14 cents per yard. Only 5,136 cubic yards were taken out during the past year under the first-named contract, by which the same was terminated.

A draught of about 13 feet at low-water and 19 feet at high-water can now be carried from Tybee Roads to the city of Savannah.

WORK CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

It is proposed during the fiscal year ending June 30, 1882, to raise the crest of the dam at the Cross Tides to a higher level; to enlarge the water-way at shoal places above the city, with a view of aiding the increased flow along the city wharves; to widen the gap in the Old King's Island jetty; to widen and deepen the water-way in front of the city in accordance with the present project; to further improve "The Wrecks" Channel below Fig Island by dredging, and perhaps by constructing a work to concentrate the currents through the channel and protect it from silt brought down Back River; to complete the submerged dam at the head of Elba Island, in the South Channel, as originally proposed; to build the three dams, as designed, between the islands from Elba to Cockspur, and to dredge at such points as may from time to time require it.

In addition to the foregoing, the necessary works for bank protection and channel contraction, to which reference has been made in previous reports, but for which no estimates of cost have until now been submitted, may be begun at two or three points where they will, beyond doubt, be required, no matter what plan for completing the improvements may be determined upon. Without taking into consideration, at the present time, the project contemplated in the act approved March 3, 1881, which requires an estimate to be submitted of the cost of improving the Savannah River and harbor, so as to give a channel 22 feet deep from the bar to the city with the same depth for a width of 600 feet in front of the city, it may be stated that the maintenance of the channel to be established under the project of August 28, 1873, will require an expenditure of $300,000 to $350,000 in the construction of spar-jetties, training-walls, and bank revetments.

In the project and estimate called for by act approved March 3, 1881, which will be ready before the 1st of December next, this subject of channel contraction will be discussed at greater length, and such of the works as require to be first undertaken will be definitely located and detailed estimates of their cost submitted. Additional works to be constructed later will depend for their character, magnitude, and location, in some degree, upon the effects produced by the closing dams between the islands below Fort Jackson. These dams will not be finished until some time next winter.

This work is in the collection district of Savannah. Savannah is the nearest port of entry.

The amount of revenue (duties on imports, tonnage, dues, &c.) collected for the last fiscal year was $112,718.71.

The estimated cost of the works of improvement that have been authorized is $481,869.64.

This sum does not include the cost of bulkheads along the amended water-way, and of acquiring the necessary land on Fig and Hutchinson's islands, nor the cost of wing-dams and training-walls and bulkheads at other points, nor the increased cost of closure-dams.

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CHART OF CROSS TIDES, SAVANNAH RIVER, GA.

showing new and old soundings and site of dam

Accompanying annual report for fiscal year ending June 30, 1881.

D. A. Gillmore

Lieut. Col. of Engrs., Bvt. Maj. Gen. U.S.A.



Scale $\frac{1}{2400}$

Yards

100 50 0 100 200 300 400 500

Note: The underlined Soundings were made in May 1881.
The other Soundings are from the Coast Survey Chart of 1874.
Soundings reduced to mean low water and expressed in feet and tenths.

6 feet curve.....
12 " " - - - - - - - -
18 " " — — — — — —
mean low water _____

Since the works of improvement were commenced, the following appropriations have been made:

By act of Congress approved June 23, 1874	$50,000
By act of Congress approved March 3, 1875	70,000
By act of Congress approved August 14, 1876	62,000
By act of Congress approved June 18, 1878	70,000
By act of Congress approved March 3, 1879	100,000
By act of Congress approved June 14, 1880	65,000
By act of Congress approved March 3, 1881	65,000
	482,000

Of this amount there had been expended up to the close of the fiscal year ending June 30, 1881, including outstanding liabilities, the sum of $311,528.22.

The following papers accompany this report:

Chart of the Cross Tides, Savannah River, Georgia.
The annual report of Mr. S. L. Fremont, assistant engineer.
Letter from the mayor of Savannah, with table, giving chief articles of export.
Table of commercial statistics, furnished by the collector of the port.

Money statement.

July 1, 1880, amount available	$157,527 87	
Amount appropriated by act approved March 3, 1881	65,000 00	
		$222,527 87
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	46,770 36	
July 1, 1881, outstanding liabilities	5,285 73	
		52,056 09
July 1, 1881, amount available		170,471 78
Amount (estimated) required for completion of existing project		350,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		350,000 00

Abstract of proposals for dredging in the Savannah River, Georgia, opened October 2, 1880

No.	Bidders.	Price per cubic yard.	Commence the work.	Complete the work.
1	Frank Pidgeon, jr., New York ...	$0 19	Within 15 days from date of contract.	On or before October 15, 1881.
2	The American Dredging Company, Philadelphia, Pa.	0 14	On or before Oct. 15, 1880.	June 30, 1881.

Abstract of contract for dredginy in the Savannah, River, Georgia.

Contractor.	Nature of work.	Price per cubic yard.	To be completed.
American Dredging Company	Dredging	$0 14	On or before June 30, 1881.

REPORT OF MR. S. L. FREMONT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., July 1, 1881.

GENERAL: I have the honor to submit the following report of progress upon the works of improvement of the Savannah River for the fiscal year ending June 30, 1881.

Improvements were made at the following places:

1. At the Cross Tides River.

2. At the channels along the old jetty and King's Island.
3. At the shoals at "Garden Bank."
4. At the new ship channel known as "The Wrecks."
5. At the channel at the "Obstructions," near Elba Island.
6. At the submerged dam in South Channel.
7. At "Screven's Point."
8. At "Fig Island."
9. At the Oyster Bed Shoal, near the red light.
10. At Tybee Knoll and Saint Michael's Channel.
11. At the dry dock in Saint Augustine Creek.

THE SUBMERGED DAM AT THE CROSS TIDES.

At the close of the last fiscal year the contractor for this work had completed it with the exception of placing 244.95 cubic yards of riprap stone of the superstructure.

This remnant was put in place during the months of July, August, and November, the last being laid on the 13th November, which completed the work.

This dam has withstood the most thorough freshet tests that have been known in the Savannah River in many years, and without injury. The only injurious effect of this series of freshets has been in eating away a small portion of the Argyle Island shore, at the end of the dam. This was caused by the eddying of the water produced by the great volume passing through the opening (or low place left in the wall, for purposes of navigation) and the consequent strong current.

This erosion has now been secured by a mattress of brush 1 foot in thickness, 26 feet in width, and 155 feet long, loaded with half a cubic yard of stone to each linear foot in length of mat. This opening should now be closed, or the dam raised up to the general level, and the passage of small vessels and flats made near the other end of the dam, where the depth of the river above and below is much less, and the force of the current correspondingly weak. When this dam is raised up to the low-water line, as I think it should be at an early day, there will be no want of water in front of the city of Savannah for a water-way and anchorage 800 feet in width, as desired by the business men of the city, who look forward to its necessity within a reasonably short time.

The new channel below the city, south of "The Wrecks" shoal, has now assumed such proportions, and the old channel has been so well closed up, that no danger need be apprehended from a large increase of the volume of water in Front River.

This dam is no doubt the key to all improvements of the water-way above Fort Jackson.

THE CHANNEL AT KING'S ISLAND AND OLD JETTY.

This channel, as shown by the soundings heretofore transmitted, has not maintained its originally-dredged depth along the old jetty, while that portion of it connecting with the opening that was made through the old jetty has increased in depth and width.

Dredging done in both branches of this channel since July 1, 1880, amounts to 24,849 cubic yards. The work was commenced on the 16th October, and completed on the 3d day of December, 1880.

I think another crib 70 feet in length should be removed from the old jetty, giving a water-way through that structure of 140 feet in width. The channels—depth and width—from King's Island to Central Railroad Wharves have increased all the way.

THE SHOAL AT GARDEN BANK.

The channel across this shoal has been widened 75 feet, giving, with the dredging done during the last fiscal year, a channel width of 150 feet, with a low-water depth of 16 feet, which has greatly relieved the difficulties of navigation at that place.

The amount of material removed from this shoal was 18,813 cubic yards.

It is believed that the work of cutting away the salient point of Fig Island and deepening the water in its front will have a beneficial effect in removing this shoal.

THE SHIP CHANNEL AT "THE WRECKS" SHOAL.

The United States steamer Henry Burden was employed in this channel in July and August, 1880, and removed 12,019 cubic yards of material therefrom.

This channel has maintained its full depth, with the exception of a small shoal formed at the mouth of a rice-field creek, which seems to cause a perpetual deposit, and the only remedy, so far, is annual dredging. The creek must have an outlet into the river, and its sedimentary character seems to require in the channel a greater volume and consequent increased velocity of water to sweep it away.

CHANNEL AT "OBSTRUCTIONS."

This channel is near the head of Elba Island, where the river is divided into the North and South channels, and is obstructed by a sand shoal formed at the slack-water point of divergence of the two channels. It will continue to be so formed until some work is erected to aid the current in the northern channel in destroying any tendency to deposit sand there.

The quantity of material removed from this shoal by the United States steamer Henry Burden in August and September, was 13,276 cubic yards.

THE SUBMERGED DAM IN SOUTH CHANNEL.

This dam was commenced during the last fiscal year by the contractor, R. C. McKay, of Philadelphia, and 425 linear feet of apron-dam was laid.

In December of the present year, his attorney, R. G. Ross, recommenced the work, and continued it in a slow and feeble manner until April 13, when it was wholly suspended.

The entire apron course, from high-water to high-water, was completed in March, giving an aggregate length of dam of 1,461 feet. The mats for a second course, 128 feet in length, were laid, and from that point (602 feet from high-water on the southern shore) the double mats (second and third course combined) were commenced, and 215 linear feet laid. This leaves about 560 feet of the double mat to be laid to complete the dam according to the original design; less than a week's work for a suitable force.

This dam consists of an apron course of logs, 12 inches in diameter and 24 feet in length, laid parallel with the direction of the current, and fastened together by binders drift-bolted to the logs and covered with a course of stone 6 inches in thickness. Upo n this apron course a second course of similar construction only 14 feet in width is laid, and upon this a third course, 10 feet in width, is laid.

For convenience in placing them and to secure greater stability in the dam, after passing beyond a low-water depth of 6 feet, the second and third courses are combined, and the logs of both courses are fastened together with drift-bolts, and all the stone of both are placed on the top of the two courses.

This dam stands the current (here very strong) perfectly, and is having the desired effect upon the currents, so far as it has been completed.

The design in locating this dam was to allow a free passage for the flood-tide flow up the main channel, and to obstruct as much of the last quarter of the ebb-tide as possible, and deflect it into the north channel to aid in the scour of that channel; at the same time the dam was not to be raised so high as to impede the passage of the inland steamers. When these conditions have been fully complied with, it is believed the dam will be found very efficient as an aid to the improvement of the northern channel.

SCREVEN'S POINT.

At this place the shore line has been straightened by cutting away about 100 feet in width at the widest point, and extending along the shore about 1,500 feet. By doing this, an easy turn in the channel and bulkhead or wharf line has been effected.

The total amount of material removed from this point is 32,505 cubic yards. Five thousand yards more will in a short time be removed to complete this line.

FIG ISLAND.

At this point about 3⅛ acres of land were condemned by a jury for the public use in making improvements, and the damages assessed at $1,000.

All the land thus condemned has been cut away, the shore line reformed, the waterway widened more than 150 feet, and a 10-foot channel carried up to that shore.

The whole amount of material removed in making this improvement is 118,229 cubic yards, exceeding somewhat the allotment for the work, but it was found impossible to accomplish the desired object—a good line—without removing all that has been done.

OYSTER BED SHOAL.

This was undertaken as soon as the stormy season of winter and spring was considered over, and though due diligence has been used with the managers of the old dredge, yet the work is not half completed.

The bottoms of two vessels have been found exactly where the channel formerly existed, and though a few pieces (together with the sand and like material found around them) have been removed, yet until the contractor has taken out the fragments of the wrecks, all our dredging in the vicinity amounts to but temporary relief.

Under the contract and your orders, I shall insist upon the full and complete removal of the fragments of the wrecks.

TYBEE KNOLL AND SAINT MICHAEL'S CHANNEL.

At this part of the outer channel the steamer Henry Burden was employed for several weeks during the winter in deepening the water. Considerable improvement was made, some of which remains, while portions have shoaled up and give some trouble to passing vessels of large draught.

Along the northern edge of this channel, across a portion of Calibogue Sound, in my judgment, a jetty or training-wall of timber and stone should be placed, and it should be undertaken with as little delay as possible. On the accompanying sketch of the river I have shown its location.

THE REMOVAL OF THE DRY-DOCK OBSTRUCTION IN SAINT AUGUSTINE CREEK.

The old dry-dock that was sunk during the late civil war, at the confluence of Thunderbolt River and Saint Augustine Creek, has been removed, under a contract with Mr. John G. Smith, of Charleston, S. C., who completed the work early in September.

Everything was removed to a low-water depth of 10 feet. No obstruction above that depth now exists, though for a short time after the removal of the "blown up" fragments of this wreck some live oak tree tops, said to have been sunk alongside, seemed to offer some obstacle to passing vessels. They have since disappeared, and no complaint has been received from persons navigating these waters.

DREDGING.

The dredging by the United States suction-dredge Henry Burden at "The Wrecks" Channel was 12,019 cubic yards; at the "Obstructions," 13,276 cubic yards; at the Upper and Lower flats, 10,350 cubic yards; and at Tybee Knoll 23,771 cubic yards; total, 59,416 cubic yards. Work was suspended on January 22, 1881, and the dredge sent to Charleston, S. C.

Under contract with the American Dredging Company, 203,668 cubic yards of material have been removed from the Savannah River and Harbor, in addition to 5,136 cubic yards of a previous contract. This gives a total amount of material removed during the fiscal year by dredging of 268,220 cubic yards.

WIDENING THE HARBOR.

The amount of land damages on Hutchinson's Island has not yet been determined, but it has been reduced to the actual cost of a change of the improvements made upon the lands to be cut away. The city has, I learn, agreed to supply an equal amount of land in the rear, to parties whose lands will be taken for the improvements.

I believe that $75,000 will be ample to make all the changes of mills, wharves, marine railway, &c.

CONCLUSION.

In concluding this report, probably the last one of this work that I shall ever make to you, I desire to invite your attention to the somewhat sudden but very large present and prospective increase of the commercial business importance of the port of Savannah.

I have in sundry previous communications upon this subject stated in detail the extensive railway connections and combinations by which it seems beyond a doubt that Savannah is to be the center of a system of transportation both by land and water, and of transshipment for a vast amount of the products of the great West, to foreign as well as domestic points, and in a short time to become also a large importing port for the same great western markets of this country.

If there were any doubts upon this subject, they would all be removed by the well-known extraordinary efforts that are now being put forth by the able head of the railway and steamship management here to increase the number of steamships, and add to the railway facilities in connection therewith, at Savannah, such as wharves, grain elevators, and the like.

I inclose a statement from the collector of customs of the port, giving the commercial and statistical information needed with this report.

The project and estimate for the further improvement of the Savannah River will be submitted, as directed, jointly with Captain Greene.

I am, very respectfully, your obedient servant,

S. L. FREMONT,
Assistant Engineer.

General Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, U. S. A.

LETTER FROM THE MAYOR OF SAVANNAH, GEORGIA.

CITY OF SAVANNAH, MAYOR'S OFFICE, *May* 28, 1881.

DEAR SIR: Referring to your letter of March 10, requesting information in relation to the business of this port, I now have the pleasure to hand you inclosed a tabular statement showing the principal articles exported the past four years. It will be observed that there has been a regular and decided increase of business, each succeeding year showing a large excess over the preceding one. With reference to imports, the collector's statements show a handsome increase from year to year, they having reached at this time most gratifying results.

The customs duties collected during the past year largely exceed those of any previous years in the history of the city.

The tonnage statistics show the same general results. A greater number of vessels has been required, and it is noticeable that they have been, as a rule, of larger capacity than have ever before been employed in the trade. In this connection it is proper to notice the very great improvement in the steamships engaged in the coasting trade between this and northern ports.

The fleet of ocean steamers owned and managed by the Ocean Steamship Company, of this city, are not surpassed by any steamships engaged in the coastwise trade of this country. The requirements of this trade call for, and it is confidently expected ere long will be supplied with, a daily line of first-class steamships between this point and New York.

The opening of new lines of railroads and recent connections and combinations of old lines with lines extending to the West and Northwest have added largely to the business of the port, and point unmistakably to an increased ratio of business in the future. These and other considerations imperatively demand a sufficient depth of water in the river to allow the largest ships to pass to and from the wharves in the city to the ocean without difficulty.

It is gratifying to note that the operations for the improvement of the river, made under your directions, have been successful; the depth of water has been increased and channel widened and much improved.

Very respectfully, yours,

JOHN F. WHEATON, *Mayor*.

General Q. A. GILLMORE.

TABLE A.—*Chief articles of export, port of Savannah, Georgia.*

Season.	Cotton, upland and sea island.	Naval stores.		Timber and lumber.	Yarns and domestics.	Wool.
		Rosin.	Spirits turpentine.			
	Bales.	*Barrels.*	*Barrels.*	*Feet.*	*Bales.*	*Pounds.*
1877–'78	623, 293	177, 104	31, 138	69, 347, 047	27, 005	1, 088, 473
1878–'79	699, 726	177, 447	34, 368	70, 251, 720	32, 626	1, 155, 273
1879–'80	749, 008	234, 421	46, 321	71, 253, 025	42, 763	1, 291, 937
1880–'81	900, 000	290, 000	60, 000	71, 000, 000	45, 000	1, 450, 000

Season.	Hides, undressed.	Fruit.		Vegetables.			Rice.
	Pounds.	*Barrels.*	*Boxes.*	*Barrels.*	*Boxes.*	*Car lds.*	*Casks.*
1877–'78	912, 486	1, 218	27, 445	3, 810	50, 621	66	.....
1878–'79	905, 199	2, 663	54, 334	2, 728	82, 030	79	31, 357
1879–'80	1, 076, 608	3, 959	99, 027	6, 219	166, 064	91	38, 754
1880–'81	1, 100, 000	4, 500	100, 000	7, 000	200, 000	150	40, 000

In the above table, the figures are estimates for the year 1880–'81, but are regarded as strictly conservative; of the 900,000 bales of cotton estimated for the year ending August 31, 1881, there have been received up to May 24, 1881, 848,980 bales, and the receipts of other articles, up to the present time, indicate that the estimates will be fully verified.

SAVANNAH, GA., *May* 24, 1881.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Savannah, Ga., from January 1, 1878, *to December* 31 1880.

VESSELS ARRIVED.

Years.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1878.....	322	385, 532	10, 688	61	45, 208	1, 576	326	235, 787	5, 814	709	666, 527	18, 078
1879.....	319	411, 794	8, 235	30	21, 994	439	279	198, 040	3, 960	628	631, 788	12, 634
1880.....	338	446, 881	9, 996	14	7, 724	170	244	172, 224	3, 533	596	626, 829	13, 699

VESSELS CLEARED.

1878.....	378	418, 958	10, 475	64	40, 128	1, 255	260	183, 757	5, 375	702	642, 843	17, 005
1879.....	365	442, 734	8, 834	36	24, 891	497	223	156, 470	3, 129	624	623, 095	12, 460
1880.....	310	434, 864	10, 108	26	12, 536	271	242	168, 255	3, 446	578	615, 655	13, 825

Years.	Value of exports.	Value of imports.	Duties collected.
1878	$24, 014, 625 00	$505, 596 00	$23, 364 35
1879	22, 556, 755 00	378, 782 00	27, 778 73
1880	26, 129, 896 00	660, 974 00	78, 458 41

1880.—Tonnage dues and other collections, $34,260.30.

J 6.

IMPROVEMENT OF SAVANNAH RIVER, GEORGIA.

The act approved March 3, 1881, appropriated the sum of $15,000 for "improving Savannah River, Georgia," and it is presumed, inasmuch as the same act separately provides for improving Savannah Harbor and River, and Savannah River above Augusta, that the money is properly applicable only to that portion of the river between the two stretches last named, namely, from Augusta to the Cross Tides, 4 miles above the city of Savannah.

This is the first appropriation made by Congress for this work

This portion of the river was examined under my direction in September and October, 1880, by Mr. S. L. Fremont, assistant engineer.

The results were transmitted to the Chief of Engineers with my report dated December 22, 1880.

The distance between the cities of Savannah and Augusta is 108 miles in a straight line, and by water about 248 miles.

For the greater part of the year this portion of the stream is navigable for steamboats drawing from 4 to 5 feet, but during the dry season in autumn the water is very low at various places, with depths of only 2 to 3 feet on some of the shoals, and boats usually have to discharge and receive their cargoes at some point below Augusta.

The principal obstructions to navigation are shoals, or bars of sand,

and snags, or floating timber. Pile obstructions were found at two places.

The project for improving the river, as recommended in the report above referred to, comprises the following works:

1. Narrowing the river by low wing-dams where excessive widths produce or maintain shoals.

2. Aiding the accumulation of silt between the wing-dams by low and light hurdle traverses.

3. Protecting the banks, where needed, by thin, flexible brush mattresses, weighted with stone, or in some other suitable manner.

4. Cutting off some projecting points of land.

5. Removing existing pile obstructions.

6. Removing snags, floating timber, and overhanging trees.

7. Aiding the formation of the low-water channel, in a few localities, by dredging.

The object of these works is to procure a low-river navigable depth of 5 feet, and their cost is estimated at $91,000.

The obstructions formed by sand-bars that should be removed are all within 100 miles of Augusta by river.

The worst exist just below that city, and are known as Gardner's Bar and Course's Bar. Snags and floating trees are scattered along the whole distance, from Augusta to near Savannah.

OPERATIONS CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

It is proposed to expend the appropriation of $15,000 in beginning the work of improvement by removing the most serious snag-obstructions, probably including those in that part of the river known as "King Creek," about 96 miles below Augusta. The construction of wing-dams in the vicinity of Augusta may perhaps be commenced. Since none of this work can well be done by contract, no proposals will be invited.

A suitable snag-boat is now building, at an estimated cost of about $7,500, to be paid for, in part, from the Savannah River, and in part from the Altamaha River, appropriation.

Augusta is an important commercial town of Georgia, and a rapidly growing place. In 1870 its population was 15,386; in 1880, according to the tenth census, it had increased to 23,023.

It has three railroad connections with tide-water, viz, by way of Aiken and Branchville to Charleston, over the South Carolina Railroad, 137 miles; by the Port Royal and Augusta Railroad to Port Royal, 112 miles, with lateral connections at Yemassee with both Charleston and Savannah, and by the Central Railroad of Georgia to Savannah, via Millen, 132 miles.

The two last-named roads may be considered as competing with the section of the river below Augusta. As in every case of this kind of competition, a material improvement of the water-line cannot be otherwise than beneficial to those districts, which from their geographical position are naturally tributary to either route. A large area of country is directly interested in securing greater navigable channel depth at low-river stages from Augusta to tide-water.

It is desirable that a liberal appropriation for this work should be made for the next fiscal year.

This work is located in the collection district of Savannah, Ga. Savannah is the nearest port of entry.

Amount of import duties, tonnage dues, &c., collected in 1880, $112,718.17.

A table of commercial statistics, for the port of Savannah, is appended to my report on the improvement of the Lower Savannah River, for the year ending June 30, 1881.

Money statement.

Amount appropriated by act approved March 3, 1881	$15,000 00
July 1, 1881, amount available	15,000 00
Amount (estimated) required for completion of existing project	76,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	76,000 00

EXAMINATION AND SURVEY OF SAVANNAH RIVER, FROM SAVANNAH TO AUGUSTA, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, December 22, 1880.

GENERAL: I have the honor to submit the following report of an examination and partial survey of the Savannah River from Savannah to Augusta, Georgia, with preliminary estimates of cost of improvement, provided for by section 2 of the act approved June 14, 1880.

This duty was assigned to me by letter, dated June 17, 1880, and the examination was made under my direction by Mr. S. L. Fremont, assistant engineer on the Lower Savannah River improvement, whose report is herewith transmitted.

The distance between the cities of Savannah and Augusta is 108 miles in a straight line, and by water about 248 miles.

During the larger portion of the year this section of the river is navigable for steamboats drawing from 4 to 5 feet of water, but during the dry season, occurring in the latter part of summer and in autumn, the low stage of the water renders it very difficult for steamboats to reach Augusta; they usually have to discharge and receive their cargoes at some point below. Above Augusta the river trade is carried on by means of pole-boats (see report on the examinations of Savannah River above Augusta, Georgia, February 8, 1879, Appendix I 2, Annual Report of the Chief of Engineers, 1879).

The obstructions to low-water navigation for vessels drawing about 4½ to 5 feet consist chiefly of shoals or bars of sand occurring generally where the river is of undue width. There are many places with not more than from 2 to 3 feet of water over these shoals. The most serious difficulties of this description are met with near the city of Augusta, and within 30 miles from it. Lower down, as far as King's Creek, about 100 miles from Augusta, shoals occur at greater intervals, and none with less than 5 feet water over them were found between King's Creek and the city of Savannah. The aggregate length of all the shoals reported as impeding navigation is over 3 miles.

Another class of obstructions, next in importance to the shoals, is formed by snags or floating timber. They are brought into the channel by the caving of concave banks, with timber thereon, during a high or falling stage of river. They generally remain where they fall, and often form continuous rafts in the bights of bends, where they obstruct the best, frequently the only, navigable low-river water-way. The many places between Savannah and Augusta where these obstructions exist are specified in the accompanying report.

At two places pile obstructions were found. The more serious one (between Flack's and Brigham's Bars) consists of a double row of piles,

driven during the late civil war. They have caused a great accumulation of drift-wood above them, and have forced the current to cut a channel around the line of piles, rendering the passage difficult.

In comparing the results of the recent examination with those recorded in the report of an examination made by Capt. J. F. Gilmer, Corps of Engineers, date June 23, 1854 (printed Ex. Doc. No. 124, 33d Congress, 1st session), it is seen that many shoals which then obstructed steamboat navigation still exist, while several others have disappeared, and some new ones have been formed in places where there was good navigation twenty-seven years ago. These facts must be taken into account when the question of improving the river is to be considered.

The banks on both sides of the stream are somewhat elevated along the reaches above Augusta, and for about 25 miles below that place, and the lands extending back from these banks are generally in a high state of cultivation, cotton and corn being the staple products. Lower down the banks are low, often swampy, and densely wooded.

From data furnished by railroad surveys it appears that the low-water elevation of the river at Augusta is about 130.4 feet above mean low-tide level at Savannah. The average elevation of the city of Augusta above the same sea level was found to be 154 feet. The average surface-slope of the river at low-water, for the first 45 miles below Augusta, is from 1 to 1¼ feet per mile; lower down, only from 3 to 4 inches per mile. The current velocities ranged from ¾ mile to 3 miles per hour, varying as a rule inversely with the width of the river.

During the time occupied in making the examination the river was unusually low, the water-gauge at Augusta showing only about 7 inches above the lowest low-water that has occurred for many years. Lower down, where the stream is larger, this difference would, of course, be less, but no systematic water-gauge observations were made.

The stream was not gauged for discharge, but some idea of its magnitude at this stage may be gained from the following table, taken in connection with the velocities above mentioned.

Table of widths, average depths, maximum depth, and depth on the bars at various points between Augusta and Savannah.

Distances from Augusta.	Names of places.	Average width.	Depth.		
			On bar.	Average.	Maximum.
Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
1.6	Gardner's and Course's Shoal	660	2.7	2.25	7.0
4	Sand-Bar Ferry Bar	660	2.0	2.3	5.0
6	Blue House Bar	540	2.5	3.0	5.0
8	Canoe Cut Bar	540	2.5	3.0	12.0
10	Bugg's Bar	560	2.0	4.75	11.0
16	Twiggs' Upper Bar	465	3.0	4.8	11.0
16½	Twiggs' Lower Bar	540	4.5	3.60	11.0
45	Hayne's Cut	200	No bar.	9.0	15.0
50	Flowery Gap Bar	480	3.8	4.5	6.5
62	Brigham's Bar	460	3.0	4.7	8.5
81	Hack's Bar	440	4.5	4.75	10.0
82	Lower Three Run Bar	460	3.5	4.5	11.5
89	White Woman's Point	440	3.5	4.3	9.2
95	Burton's Ferry Bar	500	4.5	4.5	9.5
96	King's Creek	180	No bar.	9.0	20.0

EXPLANATORY REMARKS.

Cupboard Creek and Rocky Creek enter the river on its right bank, a little below Blue House Bar.

Rutter's Creek enters the river on its right bank, about 2 miles below Bugg's Bar.
Spirit Creek enters the river on its right bank, 3 miles below Twiggs' Lower Bar.
Town Creek enters the river on its left bank, 4 to 5 miles below Twiggs' Lower Bar.
McBean's Creek enters the river on its right bank, 13 miles below Twiggs' Lower Bar.

Upper Three Run Creek enters the river near Demere's Ferry, about 3 miles above Hayne's Cut, on the left bank.

Between Upper and Lower Three Run creeks the following named creeks enter the Savannah River:

On left bank, Four Mile Creek, Penbrook, and Stone Creek.
On right bank, Jobber's Creek, Telfair's Mill Creek, Sweet Water Creek, and Stony Brook.

Lower Three Run Creek enters the river on its left bank.
Rocky Creek enters the river on its right bank, near White Woman's Point.
McDougald's Creek about 2 miles below.
King's Creek is the shorter arm of the two into which the river here divides, and is preferred for navigation.

Freshets caused by the melting of snow in the mountains, and by heavy rainfalls lower down, are of frequent occurrence. They sometimes rise to considerable heights. At Augusta the water has been known to rise 40 feet above low-water. A rise of 34 feet, however, is rarely exceeded at that place, while at Briar's Creek, 133 miles lower down, the corresponding rise is 18 feet. About 15 miles above the city of Savannah a rise of 5 feet above the level of tidal high-water has been observed. It is stated that ordinary freshets rise to about two-thirds of the heights here given.

The oscillations of the tidal wave are ordinarily felt as high up as 28 miles above the city of Savannah, or about 45 miles from Tybee Roads.

Owing to the alluvial nature of the soil, its slight elevation above the low-water surface in the reaches below Augusta, and the winding course of the river, a more or less active erosion of the concave bends, and a building out of the opposite points occur during the high and falling stages. Chutes and cut-offs are ultimately produced, and the mass of materials thus scoured out and carried off causes new changes in the reaches lower down. Many "cut-offs" have occurred since the examination of 1854, and several within the last few years.

To improve the river thoroughly below Augusta will, therefore, require a more comprehensive system of works than is needed for the Upper Savannah River. There the principal obstructions consist of ledges of rocks, numerous bowlders, and gravel shoals; and a channel cut through them may be expected to be comparatively permanent. It is different with the low bottom lands and alluvial bed and banks of the river between Augusta and Savannah. Rock was met with at Hayne's Cut only, 45 miles from Augusta, and there it consisted of soft sandstone, and did not obstruct the water-way. At Twiggs' Lower Bar, 16½ miles from Augusta, some gravel was found upon the shoal; but with these exceptions all the shoals were composed of fine sand.

The plan of improvement suggested by Mr. Fremont consists essentially in narrowing the river by low wing-dams of brush and stone, at points where excessive widths produce shoals; in aiding the formation of the low-water channel in a few localities by dredging; in removing snags, floating and overhanging trees, and pile obstructions, and in cutting off some projecting points. The object of these works is to establish a low-river navigable depth of 5 feet, and it is thought that this can be accomplished by narrowing the stream to a low-water width of about 400 feet, or less.

The number of snags, &c., to be removed, according to the report, is between 1,300 and 1,400; and the estimated total cost of the improvement, including 10 per cent. for engineering and contingent expenses,

and the purchase and equipment of a snag-boat is placed by Mr. Fremont at $84,451.

It appears that the plan does not provide for shore protection, which will doubtless be indispensable at several points where the currents of the narrowed channel would impinge more seriously than now upon the concave bends below the wing-dams.

As it is not known whether the wing-dams will settle to any considerable extent, it will, perhaps, be better to assume for them in the estimate a minimum width of 16 to 18 feet, instead of 10 feet as suggested in the report. There is no established rule for fixing the distance between such wing-walls. At Saint Charles, Mo., where satisfactory results were obtained, it was assumed that a spur jetty will protect one and one-fourth times its length of shore above, and two and one-half times its length below. If these proportions are taken at 1 and 2 respectively, the number and aggregate length of jetties estimated for in Mr. Fremont's report may be reduced about one-half.

The principle upon which the works should be designed is to increase the flow and depth in the selected channel during the low-water season without offering material obstruction to the discharge of floods, during which period the works should still tend to keep the main currents in the low-water channel. For this purpose the wing-dams should be comparatively low, being elevated but little above the low-water line, and they should gradually rise from the border of the channel towards the bank to prevent scouring eddies at the head and to form a good connection with the bank.

The low-water currents will be better directed into the channel if the spaces between the spurs are filled up to some extent, and to promote the accretion it is believed that between every two jetties one or two light and low hurdle traverses could advantageously be placed. This has been done on some western rivers. As the depths of the Savannah River where such traverses would have to be built are nowhere considerable, their construction would offer little difficulty, and, as suitable material is abundant, it is supposed that they could be built at the rate of 25 cents per linear foot.

For protecting the banks it is recommended to use thin, flexible brush mattresses, that will readily adapt themselves to irregularities in the slope of the bank. They should be weighted with enough stone to keep them in place. This kind of protection should not cost more than 75 cents per linear foot of shore line.

It is quite possible that it will be necessary, sooner or later, to connect the ends of the wing-dams by low training-walls in many places, in order to fix definitely the borders of the low-water channel. But as wing-dams are not to be dispensed with and may alone suffice, and as a low training-wall without such dams might be broken through during heavy freshets, and the channel transferred to the wrong side, no estimate is now made of the cost of training-walls.

The work described will, no doubt, improve the stream to the extent of accommodating boats drawing about 5 feet of water during the low-water season. But as the river is not naturally fixed in its regimen, it must be expected that in time new difficulties and obstructions will be developed at other points, although it is impossible to say how soon it may be necessary to undertake improvements at points where good navigation now exists. It is believed that the necessary supplementary works will not be extensive or costly.

The recommendation of Mr. Fremont that the government should own and operate its own snag-boat, as is done on the principal western rivers,

is approved. If appropriations be made for improving certain other rivers in South Carolina and Georgia, more or less obstructed by snags, the boat could be employed elsewhere when not required on the Savannah River. A light-draught tow-boat to assist the snag-boat, with two scows for receiving and taking away the trees, are included in the estimate.

No appropriation has ever been made for improving the Savannah River between Augusta and Savannah.

The works at the Cross-Tides, 4 miles above the last-named city, and some dredging between the Cross-Tides and Savannah, formed a part of the plan of improving the tidal compartment of the river, without reference to the navigation above the Cross-Tides, and were paid for from the appropriation for improving the Savannah Harbor.

Attention is invited to some statistics given in the accompanying report, concerning the commerce on that portion of the river under consideration.

Augusta possesses three short railroad connections with tide-water, viz, by way of Aiken and Branchville to Charleston, over the South Carolina Railroad; by the Port Royal and Augusta Railway to Port Royal, with lateral connections at Yemassee with both Charleston and Savannah; and by the Central Railroad of Georgia to Savannah, by way of Millen. The Savannah River lies between the road last named and the one leading to Port Royal.

ESTIMATES OF COST OF IMPROVING THE SAVANNAH RIVER, BETWEEN THE CITIES OF SAVANNAH AND AUGUSTA, GEORGIA, SO AS TO ESTABLISH A PERMANENT LOW-WATER CHANNEL NOT LESS THAN 5 FEET.

10,000 linear feet of wing-dams, at $3	$30,000
20,000 linear feet of hurdle traverses, at 25 cents	5,000
8,000 linear feet of shore protection, at 75 cents	6,000
30,000 cubic yards dredging, at 20 cents	6,000
Removing projecting points of land	2,000
Removing pile obstructions	1,000
Removing 2,000 snags, &c., at $5	10,000
Add 10 per cent. for engineering and contingent expenses	6,000
Add 1 snag-boat, machinery, and outfit	25,000
Total	91,000

This work is located in the collection district of Savannah.

Savannah is the nearest port of entry.

The amount of revenue collected at the nearest port of entry during the past fiscal year was $61,126.65.

The following papers are sent with this report:

1. Report of Assistant Engineer S. L. Fremont.
2. Three sheets of tracings, marked 1, 2, and 3, respectively.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. S. L. FREMONT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, Ga., November 19, 1880.

GENERAL: In compliance with the instructions contained in your letter of the 6th of September, 1880, I have the honor to submit the following report of the examination and survey of the Savannah River between the cities of Savannah and Augusta.

INTRODUCTORY REMARKS.

The sources of the Savannah River are found in the mountains of Northeastern Georgia, and its general course is southeast. The channel is a very tortuous one, which makes the entire length of the river 450 miles, while the direct distance or length of territory drained by it is only about 250 miles.

It is estimated that the extent of country drained by this river and its tributaries is about 8,200 square miles.

No portion of this river above Augusta is navigable for steamers, but pole-boats have for many years been used as a means of transportation for the products and supplies of and for the country bordering that stream.

The tonnage from this region has of late years become so great that the aid of the general government has been successfully invoked to improve the navigation above Augusta sufficiently to enable light-draught steamers to ascend it for a distance of some 50 or 60 miles. By means of an appropriation made at the last session of Congress, this work of improvement, it is understood, is now proceeding.

South of Augusta the river is navigable for a considerable portion of the year for steamers drawing 4 to 5 feet of water, but during the dry seasons of summer and autumn the low stages of water render it very difficult for these steamers to ascend as high up as Augusta.

The numerous shoals and sand-bars which we find at various places along the upper portion of this "Middle Savannah River" present serious obstacles to low-water navigation, as frequently not more than 2 to 3 feet of water is found to cover them.

These shoals are of course caused, in most cases, by the widening of the bed of the river. Freshets above the city of Savannah, produced by the melting of the snows in the mountains and heavy rainfalls lower down, cause frequent overflows of the river banks, doing much injury to the crops of cotton and corn, and cutting away the shores.

The most serious difficulties that the steamers navigating the river have to encounter are met with near the city of Augusta and within 30 miles of it, though sand-bars are found for about 104 miles below to King Creek and Herschman's Lake.

There are no places below King Creek that will be considered, there being no shoals with less than 5 feet of water. Below this point Haga Slaga Shoal was examined, but no improvement other than the removal of snags is required.

From Haga Slaga a general examination was made, and the distances were approximately obtained from the most reliable authority.

It was found that an accurate instrumental measurement of the whole distance was impracticable, since the cost would be too great to be justified by the appropriation for the survey.

The instrumental observations were made by my assistant, and a general examination by myself.

The current velocities at different points are very variable. They were at some places found to be equal to 3 miles per hour, or 4.4 feet to the second, while in other places, where the stream is much widened, the velocity of the currents was less than $\frac{3}{4}$ of a mile per hour, varying generally with the width of the channel or water-way and seldom from a difference of level.

Next to the obstructing sand-bars, the greatest impediment to navigation by the river steamers is found in the continuous *rafts of floating timber* that are found in the "bights" or on the concave sides, and occupying the best, and often the only, navigable waters at the low stages of the river.

NAMES, POSITION, AND DESCRIPTION OF THE MOST IMPORTANT OBSTRUCTIONS, IN THE ORDER THEY OCCUR, DESCENDING FROM AUGUSTA, WITH A PROJECT FOR THEIR REMOVAL AND AN APPROXIMATE ESTIMATE OF THE COST.

I. GARDNER'S SHOAL.

Opposite the lower part of the city, and extending down to and connecting with "*Course's Shoal*," forming together a shoal of more than $1\frac{3}{5}$ miles in length (see chart Sheet I, Fig. 1). This continuous shoal is the most serious obstruction met with during low-water navigation. Steamers of the lightest draught cannot pass it, and are compelled habitually to lighter their freight from near the Port Royal Railway Bridge to and from the city of Augusta. It is therefore proposed to treat these as one long shoal, and by jetties as wing-dams to reduce the width of the water-way to 350 feet. This will require the construction of twenty-seven jetties—twenty along the South Carolina shore and seven on the Georgia side of the river. They should be 10 feet in width, 3 feet in height, and will vary in length from 50 feet to 375 feet. The aggregate length of the whole will be 6,135 feet, covering a distance of 7,500 feet on the South Carolina side and 1,500 feet on the Georgia side (see chart Sheet I, Fig. 1). It is proposed to construct them of brush, with small log—bottom and top—binders, and

load them with three cubic yards of riprap stone to every hundred square feet of surface (see chart Sheet I, Fig. 8). For further description see page 26 of this report.

Most excellent brush for this purpose, including the willows, are found in great abundance along the banks of the river, and covering stone is also very convenient.

After careful inquiries as to the cost of materials, I have estimated the cost of these jetties at $2 per linear foot.

From this estimate I make the cost of improving the first 8,500 linear feet of this river, commencing at Augusta City Bridge, as follows:

Estimate.

For 6,135 linear feet of jetty, at $2, $12,270. The works of improvement will extend along the shore line for a distance of 8,550 feet. To facilitate and properly direct the scour of a channel along the axis of this water-way, as indicated by the broken line, a dredge might be advantageously employed to cut a channel 30 feet wide, 2.3 feet deep, for 8,000 feet, removing about 20,500 cubic yards of material, at a cost of 18 cents per cubic yard, equal to $3,690.

This will give a total of $15,960 for rendering navigable at low-water the first 1⅗ miles of the river from Augusta, much the most difficult portion of the river to navigate, and requiring the most expensive improvements.

The next shoal that gives trouble at low stages of the water is known as

II. SAND-BAR FERRY BAR.

This bar seems to have formed since the survey of 1853. It is over 2,200 feet in length, and requires jetties over an extent of shore line of 2,500 feet. Twelve jetties will be required here—six on the South Carolina side and five on the Georgia shore—aggregating in length 2,065 feet (see Sheet I, Fig. 2). A directing channel here, 30 feet wide and 3 feet deep for a distance of 1,500 feet, should be made.

Estimate.

Using the same kind of jetties, the cost will be—

For constructing 2,065 linear feet of jetties, at $2 per linear foot	$4,130
For removing 5,000 cubic yards of material with a dredge, at 18 cents, the cost will be	900
Total for improvement	5,030

III. BLUE HOUSE BAR.

This shoal, about 400 feet in length, is the next in order as we descend the river. Extent of improvement is 2,100 feet in length.

It will require fifteen jetties—six on the Georgia side and nine on the South Carolina side of the channel—the aggregate length of which will be 1,470 linear feet.

The scour of this channel should be assisted by dredging a channel 400 feet long, 30 feet wide, and 2.5 feet deep (see Sheet I, Fig. 3).

Estimate.

For constructing 1,470 linear feet of jetty, at $2 per foot	$2,940
For dredging about 1,100 cubic yards of material, at 18 cents per yard	198
Total for this improvement	3,138

IV. CANOE CUT BAR.

This shoal is about 500 feet in length, and will require for its proper improvement 9 jetties, the total length of which will be 1,020 feet. Dredging for a distance of 500 feet will be required, the cut having a width of 30 feet and a depth of 2.5 feet.

Extent of the works, 1,300 feet (see Sheet I, Fig. 4).

Estimate.

For constructing 1,020 linear feet of jetty, at $2	$2,040 00
For dredging 1,388 cubic yards, at 18 cents	249 84
Total	2,289 84

V. BUGG'S BAR.

This shoal extends a distance of 250 feet, but the extent of the line of jetties to remove it will be almost 1,450 feet.

The number of jetties required is eight, and aggregate in length 1,295 feet—four jetties on either side of the river. Drirecting-channel 300 × 30 × 3 feet = 1,000 yards (see Sheet I, Fig. 5).

Estimate.

For the construction of 1,295 feet of jetties, at $2 per linear foot	$2,590 00
For dredging 1,000 yards required here, at 18 cents	180 00
Total	2,770 00

VI. TWIGGS' UPPER BAR.

This shoal is about 1,600 feet in length, and will require for its improvement twenty-six short jetties, aggregating in length 1,775 feet. Extent of the line of improvement is 1,800 feet (see Sheet I, Fig. 6). Dredging here a channel 1,500 × 30 × 2 feet = 3,333 yards.

Estimate.

For construction of 1,775 linear feet of jetties, at $2 per linear foot	$3,550 00
For dredging 3,333 yards for this place, at 18 cents	266 64
Total	3,816 64

VII. TWIGGS' LOWER BAR.

This shoal is about 300 feet in length, while the works for improving it will extend over a distance of 1,175 feet. There will be required here 7 jetties, aggregating in length 990 feet (see Sheet I, Fig. 7).

Estimate.

For constructing 990 linear feet of jetties, at $2 per linear foot	$1,980 00

No dredging required here.

VIII. HAYNE'S CUT.

At this point the river has cut across a bend and made two channels. The "cut-off" next the South Carolina side is the best channel at low-water, and by removing the floating and overhanging trees, cutting away the two shaded points "P" and "Q," and constructing a low dam of brush and stone 3 feet high, across the old channel at its narrowest and shoalest point, E, R, the new channel will be made navigable and convenient at all seasons of the year (see Sheet II, Fig. 1).

Estimate.

For removing sixty floating trees of the three sizes as classed in this report at an average cost of $9 each	$540 00

No dredging required here.

For constructing a brush and stone dam 12 feet wide and 3 feet high and 205 feet long, at $2.50 per foot, with 10 per cent. added for contingencies, and we have	563 75
For clearing the timber from the points "P" and "Q," to allow the water to cut them away—the clearing equal to one acre—and for excavating a a ditch to aid the scour	350 00
For cutting off and removing overhanging trees	150 00
Total	1,603 75

It is believed that by cutting off the trees and heavy growth along the banks for the distance desired, those points of land will be removed by the action of the water. No dredging.

IX. FLOWERY GAP BAR.

The shoal at this point is about 200 feet in extent, and will require twelve jetties of an aggregate length of 825 feet. The extent of the improvement along the shore will be about 1,000 feet (see Sheet II, Fig. 2).

Estimate.

For the construction of 825 linear feet of jetties, at $2 per foot $1,650 00

X. BRIGHAM'S BAR.

This shoal extends for a distance of about 1,600 feet, and the extent of the works of improvement will be 1,930 feet on the South Carolina and 900 feet on the Georgia shore.

The number of jetties required on the South Carolina side is thirteen, aggregating in length 1,280 feet. On the Georgia side eleven jetties are required, and their united length will be 620 feet. The total length of jetties required for this place is 1,900 feet (see Sheet II, Fig. 3).

Estimate.

For constructing 1,900 feet of jetties, at $2 per linear foot $3,800 00
No dredging required here.

XI. HACK'S BAR.

This shoal is only 75 feet in length, and the extent of the works for removing it will be 540 feet long. The jetties, five in number, are all required on the South Carolina side. Their united length will be 415 feet. (See Sheet II, Fig. 4.)

Estimate.

For constructing 415 linear feet of jetties, at $2 per foot $830 00
No dredging required here.

XII. LOWER THREE RUNS.

The length of this shoal is 500 feet, and the shore line of improvement extends 1,300 feet. There will be nine jetties, and their aggregate length will be 935 feet.

In addition to the improvement by jetties, about forty snags or floating trees should be removed. (See Sheet II, Fig. 5.)

Estimate.

For constructing 935 linear feet of jetties, at $2 per foot	$1,870 00
For removing forty snags, at $10 each	400 00
Total	2,270 00

XIII. WHITE WOMAN'S POINT.

This shoal is about 200 feet in extent, and the extent of the works to remove it along the South Carolina shore is 700 feet.

Six jetties will be required, having a total length of 510 feet. (See Sheet II, Fig. 6.)

Estimate.

For constructing 510 linear feet of jetties, at $2 per foot $1,020 00
No dredging required here.

XIV. BURTON'S FERRY BAR.

This shoal is 200 feet in extent, and the shore length of the works necessary to improve it will be 1,000 feet. Seven jetties, all on the Georgia shore, will be required, having an aggregate length of 765 feet. (See Sheet II, Fig. 7.)

Estimate.

For constructing 765 linear feet of jetties, at $2 per foot $1,530 00
No dredging required here.

XV. KING CREEK.

This creek seems to have existed for many years, and is simply a "cut" across several bends of the river near Herschman's Lake. It is about 1½ miles in length, and of late has so much improved that it seems to carry an abundance of water for all the

purposes of navigation, at any stage of the river, and if the floating and overhanging trees were removed, some of the salient points along the bank cut away by the action of the currents—being cleared of their timber—and the old channel of the river slightly obstructed, a good, safe, and easy passage for steamers would be obtained. There are thirty-four piles now obstructing the head of this creek, placed there some years ago to divert the water to the old channel of the river. They are in water 10 feet deep and show 3 feet above low-water. They should be removed.

At the date of the survey made in 1853, a canal across the bend of the river was recommended as the best means of improvement here. I find, however, the flow of water has so much increased in volume through this creek, in spite of the pile dam erected at its head, to close it, that I propose its improvement in the following manner, and make it the only navigable water-way.

1. Remove all the floating timber in the creek, and cut away the overhanging trees.
2. Construct a low dam at A V, across the old channel, of timber, brush, and stone.
3. Cut the timber and brush from the points shaded and marked P, Q, R, S, T, U.

(See Sheet No. III, Fig. 1.)

Estimate.

For removing 74 floating trees, at $10	$740 00
For removing 26 overhanging trees, at $8	208 00
For cutting the timber from the points shaded, estimated at 3.10 acres, at $150 per acre, and removing old piles, $100	565 00
For cutting ditches along the lines to be scoured off in length, 1,410 linear feet, at 25 cents per foot	352 50
For constructing a low dam at "A V," 180 feet long, 4 feet high, and 15 feet wide, of timber, brush, and stone, at $4 per linear foot	720 00
Total	2,585 50

List of places requiring improvement, their distances from Savannah and Augusta, their extent and the extent of the works of improvement along the shores, the number of jetties and their aggregate length; also the material constituting the shoals.

Number.	Names of places requiring improvement.	Distances from—		Length of—		Number of jetties.	Total length of jetties.	Remarks, material, &c.
		Savannah.	Augusta.	Shoal.	Works.			
		Miles.	*Miles.*	*Feet.*	*Creek in length is (feet.)*		*Feet.*	
1	King Creek	152	96	.....	7,920	*1	180	Sandy.
2	Burton's Ferry	153	95	200	1,000	7	765	Do.
3	White Woman's Point	159	89	200	700	6	510	Do.
4	Lower Three Runs	166	82	500	1,300	9	935	Do.
5	Hack's Bar	167	81	75	540	5	415	Do.
6	Brigham's Bar	186	62	1,600	2,830	24	1,900	Do.
7	Flowery Gap Bar	198	50	200	1,000	12	825	Do.
8	Hayne's Cut	203	45	820	820	0	0	Do.
9	Twigg's Lower Bar	231½	16½	300	1,175	7	990	Gravel and sand.
10	Twigg's Upper Bar	232	16	1,600	1,800	26	1,775	Sandy.
11	Bugg's Bar	238	10	250	1,450	8	1,295	Do.
12	Canoe Cut Bar	240	8	500	1,300	9	1,020	Do.
13	Blue House Bar	242	6	400	2,100	15	1,470	Do.
14	Sand-Bar Ferry Bar	244	4	2,200	2,500	12	2,065	Do.
15	Course's Bar	246½	1½	8,500	9,000	27	6,135	Do.
16	Gardner's Bar	248	0					
	Total	.....	.....	17,345	27,515	168	20,280	

*Dam across old channel.

This table shows that all the shoals that give trouble are within 96 or 100 miles of Augusta. The shoals are composed of fine sand, except at Twigg's Lower Bar, where some coarse gravel is found. No rock was encountered on the surveys, except at Haynes' Cut, and this was a soft sandstone which could be removed with a dredge, but at present it does not obstruct the water-way.

CONCLUSION OF LIST OF IMPROVEMENTS.

This concludes the list of shoals and places where other obstructions exist, with the exception of the double row of piles between Hack's and Brigham's bars. These piles were driven to obstruct the channel during the civil war. The accumulation of drift wood has forced the current to cut a channel around them, which is now used by steamers, but the passage is difficult, and they should be removed. (See table showing location, &c., of principal obstructions, Confederate obstructions.)

The estimated cost of their removal is $1,000.

There are no obstructions below King Creek that will interfere with steamers having a draught of 5 feet or less.

The shoal at Haga Slaga does not show less than 5 feet of water at any time. The removal of "snags" is all that is required there.

THE GENERAL BEHAVIOR OF THE RIVER AS REPORTED AT VARIOUS STAGES OF THE WATER, WITH ITS ORDINARY AND GREATEST FRESHET RISE, AT VARIOUS PLACES.

The greatest rise of this river during freshets at Augusta is understood to be 40 feet above mean low-water, when the river was 4 feet deep in the streets of Augusta. The last occurrence of this was in 1875. Freshets, however, seldom rise above 34 feet from mean low-water at Augusta; 18 feet at Briar Creek, and 5 feet above high-water (tide) at the Savannah and Charleston Railroad Bridge (15 miles above Savannah).

The ordinary freshets to which the river is subject do not raise the water more than two-thirds of the elevations here given. From about 25 miles below Augusta the low alluvial lands commence, and are, as stated above, often overflowed by the river during high stages of the water. In consequence of the nature of the soil and tortuous course of the river there is a constant wearing away of the banks on the concave sides, while the accumulations on the convex shores are equally abundant. The consequence is the river constantly changes its bed, wearing away on one shore and making on the opposite, until the bends become so great and the distances so small across the necks that an unsually high rise of water cuts across and reforms the line. Many of these "cut-offs" have occurred within the last few years, and many of them since the survey made by Captain Gilmer, Corps of Engineers, in 1853.

In quite a number of places the channel has been improved by the scour and straightening caused as above described. King Creek is an especial case in point. Therefore, to maintain a permanent channel of 7 or 8 feet at low summer water, a great many spur jetties, similar to those proposed for this improvement, would be required. This project is based upon obtaining 5 feet at the lowest stages of the river at the shoalest places. I believe a depth of 7 feet at low summer water could be obtained by additional works, within a reasonable cost.

FLOATING TREES, SNAGS, ETC.

They are trees that have been washed out on the concave sides of the river by the scour in times of high-water and lay generally where they fall. At these places on the concave shores, called "bights," the deepest water is found, and when the stream is narrowed down by low summer water they not unfrequently occupy the entire available water-way, and it is with great difficulty that steamers can pass over them. This is especially the case at King Creek (see page 14 of this report).

To remove these serious obstructions, a snag-boat, consisting of a large flat with suitable machinery, should be employed. With such a machine more can be done to remove impediments to easy and safe navigation of this river with a moderate expenditure than by any other means known to me.

Should it be expedient to build a snag-boat, the cost of the lighter or flat, suited to the purpose of this work, will be about	$1,500 00
It is supposed the machinery will cost about	15,000 00
Total cost of snag-boat	16,500 00

The floating timber obstructions mentioned above are found especially at two points below King Creek, viz, at "Haga Slaga," and at "Sister's Ferry," and at other places named in the following table of snags.*

* * * * * * *

*Omitted. Printed in House Ex. Doc. No. 23, Forty-sixth Congress, third session.

Consolidated table of estimates.

1	Gardner's and Course's Shoals	$15,960 00
2	Sand-Bar Ferry Bar	5,030 00
3	Blue House Bar Shoal	3,138 00
4	Canoe Cut Bar Shoal	2,289 84
5	Bugg's Bar Shoal	2,770 00
6	Twiggs' Upper Bar Shoal	3,816 64
7	Twiggs' Lower Bar Shoal	1,980 00
8	Hayne's Cut Bar Shoal	1,603 75
9	Flowery Gap Bar Shoal	1,650 00
10	Brigham's Bar Shoal	3,800 00
11	Hack's Bar Shoal	830 00
12	Lower Three Run Shoal	2,270 00
13	White Woman's Point Shoal	1,020 00
14	Burton's Ferry Shoal	1,530 00
15	King Creek obstructions	2,585 50
16	Pile obstructions by the late civil war	1,000 00
17	Removing floating trees and snags exclusive of those estimated for	10,500 00
		61,773 73
	Add 10 per cent. for contingencies	6,177 37
		67,951 10
	To this add cost of a snag-boat	16,500 00
	Total	84,451 10

Should this work be undertaken I recommend that not less than $25,000 of the amount of the foregoing estimate be made available immediately after the approval of the act, in order to begin the work in the spring—far the best season for its prosecution.

The estimates for the improvement recommended will, I believe, be ample to remove all shoals and other obstructions, including snags, that are now so troublesome at the low stages of the river. The work should be commenced early in the spring and continued to July, when it will probably be found necessary to suspend it until November, in consequence of the great difficulty of preserving the health of the employés during the summer months.

FACE OF THE COUNTRY.

The face of the country within 25 miles of Augusta is somewhat elevated; the lands are generally in a high state of cultivation from the banks of the river back to the interior. Below that distance the lands are low—in many cases swampy—and are everywhere covered with a dense growth of timber and brush—ash, cypress, and cottonwood on the lowlands, and hickory, oak, and pine on the table-lands. Occasionally there are high bluffs extending from the river far back into the interior. In Richmond, Burke, and Screven counties there is an abundance of granite, buhr and limestone to be found. Willow and other brush grow along the bank to the water's edge, thus supplying the material for the improvements at convenient points.

DESCRIPTION AND METHOD OF CONSTRUCTION OF JETTIES.

The jetties will consist of a series of brush and stone covered mattresses, to be constructed in the following manner: Place three logs upon a platform or "ways," suited to the purpose of construction with a view of launching them into the river from the bank or near where they will be required.

Into these lower logs as binders we bore 2½-inch holes at intervals of 5 feet, and insert hickory stakes rived from the tough trees of the abundant growth in the vicinity, and wedge the lower ends. Across these lower binders compactly pile a good quality of brush and place it across it the upper binders directly over the lower ones. These binders, having been already bored at the proper intervals to correspond with the lower ones, the upper ends of the tie stakes are inserted. The upper and lower binders are then pressed strongly together, compressing the brush between them, when the tie stakes are fastened by wedging the upper ends. Should it be found necessary a few iron bolts, with nuts, can be added as ties.

These binder logs should be from 10 to 11 inches in diameter for the lower ones, and from 7 to 8 inches in diameter for the top ones. The horizontal distance between them should be 3½ to 4 feet, the mattresses being 10 feet or more in width. Upon this mattress of brush, when in position, place riprap stone to the height of about 10 inches, or at the rate of 3 cubic yards to the 100 square feet of surface. (See Sheet I, Fig. 8.)

STATISTICAL STATEMENT.

This work is located in the collection district of Savannah.
The nearest port of entry is Savannah.
The nearest light-house is Fig Island, at Savannah.
The nearest fort is Jackson.
The amount of revenue collected at the nearest port of entry during the last fiscal year was $61,126.65.

The general benefits to this portion of the country to be derived from this improvement are many, amongst them the following:

Greater facilities will be afforded for the transportation of the products and supplies of the country.

A safer, quicker, and more convenient communication with tide-water and ocean-going steamers, and a consequent reduction of the cost of transportation will be obtained. These benefits, and many others, will accrue to the planters, merchants, and manufacturers in the vicinity of the Savannah River, in both Georgia and South Carolina.

Trade and commerce thus encouraged, a large area of country will be more rapidly developed. The improvement will aid in opening and developing the country, not only in the vicinity of the river, but far back into the interior.

* * * * * * *

LEVELS.

The Port Royal Railroad levels give the elevation of Augusta as 154 feet.

Mr. James P. Carson, assistant engineer, in his report on the examination of the Savannah River above Augusta in 1878, gives the elevation deduced from barometric observations taken at the signal office at that place as 148 feet. On page 37, appendix 18, of the United States Coast Survey Report of 1876, the elevation of a bench mark near the Port Royal Railroad offices is given as 132.36 feet above sea-level. This bench mark could not be found. The elevation of the ground in the vicinity above low-water in the river at Augusta is 22.6 feet.

The elevation of low-water at Augusta, determined by observations on the *aneroid* made during the survey, was 125 feet, making the elevation of the ground in the vicinity of the Port Royal Railroad depot 147.6 feet. Therefore, the elevation of 154 feet given by the railroad levels is presumed to be the most reliable.

The *aneroid* used during the survey was carefully adjusted before leaving Savannah, but as no levels deduced from observations on it (except at Augusta) are within the range of probability, and as it was found on the return to Savannah to be considerably "out," it is supposed that it was thrown out of adjustment during transportation on the river.

Table of levels.

Places.	Distance in miles.	Fall in feet.
Augusta to Silver Bluff	18	22.423
Silver Bluff to Haynes Cut	27	29.056
Haynes Cut to Steel Creek	33	10.297
Steel Creek to Savannah	170	68.624
Augusta to Savannah	248	130.400

The above distances and slope notes refer to the river surface.

CONCLUSION.

The levels that have been obtained, and which are relied upon as correct, were taken from a bench mark at the Port Royal Railway Station at Augusta as 154 feet above sea-level. The low-water elevation of the river at Augusta is 131.4 feet above sea-level, or 22.6 feet below the bench mark. Low-water at Savannah is 1 foot above low-water at the sea-shore, hence the difference of level between the surface of the river at Augusta and Savannah is 130.4 feet. A table of the levels, as it was most practicable to obtain them, is inclosed. Three sheets of tracings showing the location of the shoals and other obstructions are also inclosed, together with three others of a former survey returned, and a general chart of the river throughout the entire distance examined.

In making this survey I have been ably assisted by Mr. James P. McLaws, civil engineer, who has conducted the field work, with the charge of a small party, very satisfactorily, and is entitled to my thanks.

I am, general, very respectfully, your obedient servant,

S. L. FREMONT,
Assistant Engineer.

Maj. Gen. Q. A. GILLMORE,
Lieutenant-Colonel, Corps of Engineers, U. S. A.

J 7.

IMPROVEMENT OF SAVANNAH RIVER, ABOVE AUGUSTA, GEORGIA.

By act approved March 3, 1881, the sum of $8,000 was appropriated for the improvement of the Savannah River, above Augusta, Ga. This is the second appropriation made by government for this work, the sum of $16,000 having been appropriated during the preceding fiscal year.

This portion of the Savannah River was examined in November and December, 1878. The report thereon was printed in Appendix I 2, Annual Report of the Chief of Engineers for 1879.

It was stated in that report that until a thorough examination could be made above Trotter's Shoal, 64 miles above Augusta, any money that might be appropriated should be expended upon that portion of the river below that shoal.

Two estimates were submitted, viz:

1. Cost of improving the river for pole-boat channel, 3 by 30 feet, from Augusta to Trotter's Shoal, 64 miles $45,000
2. Cost of steamboat channel, 3 by 90 feet, on same route 124,000

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

It was decided to confine the present improvement of the river between Augusta and Trotter's Shoal to the establishment of a pole-boat channel of 3 feet depth and 20 feet wide. This width is considered suitable for pole-boats, which are only 8 feet wide.

Proposals were invited October 26, 1880, for removing sunken rocks and gravel and building wing-dams, and a contract was made with Anderson and Blaisdell, November 26, 1880. The severe winter and the long-continued high stage of the water seriously interfered with the operations, and although the contractors had their plant ready in the early part of this year, work could not be commenced before June. It has consisted thus far in the removal of solid rock and bowlders, gravel bars, and the construction of short low dams.

The places where improvements have been made are Little Rapid Gap, Stevens' Creek Falls, and Big Rapid Gap—all within 8 miles of the city of Augusta.

The operations embrace the construction of 658 cubic yards of rock and 27 cubic yards of gravel, and in the removal of 37 cubic yards of rock from an old dam.

At the close of the fiscal year the work was making satisfactory progress.

OPERATIONS CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

Work will be continued under the existing contract.

By October, 1881, it is expected good progress will have been made, when a project for expending the appropriation of $8,000 lately made can be intelligently prepared. It is thought probable that the first appropriation ($16,000) will be expended by December, 1881.

Capt. B. D. Greene, the assistant in charge, is of the opinion that it may take $25,000, in addition to the amounts so far appropriated, to complete this improvement, and that this sum can be expended within a few months. It is reported that upon the short reaches of the river thus far improved immediate and permanent benefits have already been effected for the boat navigation.

As to the amount of commerce and navigation that will be benefited by completing this improvement, I beg leave to refer to my report of February 8, 1879, contained in Appendix I 2, Annual Report of Chief of Engineers for 1879, since no later data have been obtained.

This work is located in the collection district of Savannah, Ga. Savannah is the nearest port of entry.

Amount of import duties, tonnage dues, &c., collected in 1880, $112,718.71.

The report of Capt. B. D. Greene, Corps of Engineers, is appended.

Money statement.

July 1, 1880, amount available	$16,000 00	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$24,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	569 73	
July 1, 1881, outstanding liabilities	2,314 29	
		2,884 02
July 1, 1881, amount available		21,115 98
Amount (estimated) required for completion of existing project		21,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		21,000 00

Abstract of proposals for removal of obstructions and building dams in the Savannah River above Augusta, Ga., opened November 15, 1880.

No.	Bidders.	For removing ledges of rock.	For removing gravel.	For building wing-dams.
1	Anderson & Blaisdell, Boston, Mass	*Per cu. yd.* $4 50	*Per cu. yd.* $0 32	*Per cu. yd.* $2 60

Contract awarded at the price stated.

REPORT OF CAPTAIN B. D. GREENE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., July 12, 1881.

COLONEL: I have the honor to submit the following report upon the progress of the work of improvement of the upper Savannah River, for the fiscal year ending June 30, 1881.

SAVANNAH RIVER ABOVE AUGUSTA, GEORGIA.

A contract for the prosecution of this work was made on the 26th November, 1880.

The severe winter and continued high-water of the spring season delayed the beginning of the work until June. About the 15th of that month the contractor began operations under the supervision of his agent, Mr. Frank Blaisdell.

The work commenced upon the rapids just above the canal lock. It consists in the removal of solid rock and bowlders, gravel bars, and the construction of short and low dams, both closing and spur dams. As the water is shoal, the men work in the water, and none of the work is done from boats, except the delivery of rock upon the dams.

So far as it has gone, the work has produced an immediate and permanent benefit to the navigation of the river by the small boats that use it.

The rapidity with which the work is now going on, warrants the expectation that the first appropriation of $16,000 will be expended before December 1, and the second appropriation within two or three months more.

The absence of any regular surveys of this river renders it impossible to state the amount that may be required to carry the work to Trotter's Shoal, a distance of 64

miles. It is certain, however, that as much as $25,000 in addition to the amount already appropriated will be needed, and that amount can be expended in a few months.

Mr. R. S. Burnett, the inspector in charge of this work, deserves much credit for the intelligence and energy he has displayed in its management. He has shown the contractor how to do the work, and its success is due to his efforts.

Respectfully submitted.

BENJ. D. GREENE,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 8.

IMPROVEMENT OF SAINT AUGUSTIN'S CREEK (THUNDERBOLT RIVER), GEORGIA.

By the river and harbor act, approved March 3, 1879, the sum of $5,000 was appropriated for improving Saint Augustin's Creek, Georgia, constituting a part of the inside passage between the Savannah River and Jacksonville, Fla.

This is the first appropriation ever made by Congress for this river.

The improvement required consisted in the entire or partial removal of the wreck of a large timber dry dock, sunk during the late civil war, situated near the middle of the stream, about a mile from its confluence with the Savannah River. As stated in my last annual report, the contract for the removal of the wreck, down to 10 feet below mean low-water, was awarded on June 30, 1880, to John G. Smith, of Charleston, S. C., he being the lowest bidder.

On July 22, 1880, the contract was made, and the work was satisfactorily completed in the early part of September.

The wreck was removed to a depth of 10 feet below mean low-water.

There appears to be no necessity at present for any further improvement of the river at this point, and no other appropriation is asked.

This work is located in the collection district of Savannah. Savannah is the nearest port of entry.

Amount of import duties, tonnage dues, &c., collected in 1880, $112,718.71.

Money statement.

July 1, 1880, amount available	$5,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,582 34
July 1, 1881, amount available	3,417 66

J 9.

IMPROVEMENT OF ALTAMAHA RIVER, GEORGIA.

By act approved March 3, 1881, the sum of $5,000 was appropriated for improving Altamaha River, Georgia, being the first appropriation made by Congress for the purpose.

Section 2 of the act approved June 14, 1880, provided for an examination of this river.

This was made by Mr. W. G. Williamson, assistant engineer, in October,

1880, and the results communicated to the department with my report, dated November 27, 1880.

The Altamaha is the most important river, lying entirely within the State of Georgia, and is formed by the confluence of the Oconee and the Ocmulgee. It has a southeasterly course, and empties into the Atlantic Ocean, through Altamaha Sound, below the town of Darien. Its total length is 155 miles.

The chief obstructions to navigation consist in rock ledges, running nearly across the stream, sand-bars and snags.

An old wreck in the upper portion of the river, and piles driven during the late civil war, at two places lower down, also more or less impede the passage of vessels.

The estimate submitted with the report above named provides for the removal of about 10,500 cubic yards of rock, and of the old wreck, and the pile obstructions, as well as of several thousand snags, all in the fresh-water stretch of the river, and for dredging 8,000 cubic yards of material near to and above Darien.

The localities where sand-bars occur, and which would likewise require improvement, were not included, since it will be necessary to have them instrumentally surveyed, before a plan of improvement can be devised. The partial project submitted contemplated the establishment of a channel navigable for boats of 3 feet draught.

The cost was estimated as follows:

For a channel 200 feet wide by 3 feet deep	$61,000
For a channel 80 feet wide by 3 feet deep	30,000

As a rough estimate, the entire cost of the improvement including sand-bars, for a channel not less than 80 feet wide, with a navigable low-water depth of 3 feet, may be set down at $60,000.

OPERATIONS CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

It is proposed during the present fiscal year to expend the sum of $5,000 lately appropriated in removing snags of the worst character, and perhaps some rock bars, or reefs, so as to give a passage of about 80 feet width for light-draught steamboats. The snag-boat which is now being fitted up for employment on the Middle Savannah River will also be used on this improvement, and a part of her cost will be charged to the Altamaha River appropriation.

The work on the Altamaha cannot well be done by contract.

As to the benefits that may be expected to follow the completion of this improvement, I beg leave to refer to the remarks made in my report of November 27, 1880. No new data have been received since then.

This work is located in the collection district of Brunswick, Ga. Darien is the nearest port of entry.

The total collections of the custom-house at Darien during the calendar year 1880 were $16,806.72.

Money statement.

Amount appropriated by act approved March 3, 1881	$5,000 00
July 1, 1881, amount available	5,000 00
Amount (estimated) required for completion of existing project	55,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	55,000 00

COMMERCIAL STATISTICS.

Arrivals and clearances at port of Darien, Ga., for the year ending December 31, 1880.

VESSELS ARRIVED.

Coastwise:	
Number of vessels	66
Tonnage	21,539
Crew	489
American vessels from foreign ports:	
Number of vessels	1
Tonnage	668
Crew	13
Foreign vessels from foreign ports:	
Number of vessels	134
Tonnage	68,072
Crew	1,608
Total:	
Number of vessels	201
Tonnage	90,279
Crew	2,110

VESSELS CLEARED.

Coastwise:	
Number of vessels	55
Tonnage	17,076
Crew	393
American vessels to foreign ports:	
Number of vessels	7
Tonnage	3,589
Crew	72
Foreign vessels to foreign ports:	
Number of vessels	168
Tonnage	84,172
Crew	2,016
Total:	
Number of vessels	220
Tonnage	104,837
Crew	2,481

IMPORTS, EXPORTS, AND COLLECTIONS.

Value of exports	$1,021,904 00
Value of imports	5,600 00
Total collections	16,806 72

EXAMINATION OF ALTAMAHA RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, November 27, 1880.

GENERAL: I have the honor to submit the following report of an examination of the Altamaha River, Georgia, with partial estimates of the cost of works of improvement, as provided for by section 2 of the river and harbor act approved June 14, 1880, and assigned to my charge by letter of June 17, 1880.

The examination was intrusted to Mr. W. G. Williamson, assistant engineer, whose report is herewith inclosed.

The Altamaha River, the most important lying entirely within the State of Georgia, is formed by the confluence of the Oconee and Ocmulgee. It has a southeasterly course and empties into the Atlantic Ocean through Altamaha Sound below the town of Darien. Its length from the point of confluence named to Darien is about 155 miles.

The mean rise and fall of tides in Altamaha Sound is 7 feet. The

oscillations of the tidal wave are felt in the river as far up as 30 miles above Darien, but not beyond.

The examination was made during the latter part of October, 1880, when the condition of the river was favorable for observing shoals and other obstructions, the water-surface being then only 1 foot above the common low-water stage.

The velocities of the currents were found to be moderate, and varied from half a mile to 2 miles per hour.

The obstructions to navigation were found to consist chiefly in rock ledges running nearly across the stream, sand bars, which are generally formed where creeks or sloughs connect with the river, and snags. An old wreck in the upper portion of the river, and pile obstructions at two places in the lower reaches, also more or less impede the passage of vessels.

Mr. Williamson specifies thirty-one different localities where works of improvement appear to be needed. Only a limited number of the points indicated require to be improved, however, if a low-water navigation of 3 feet be all that is needed, as it seems to be at the present time.

The cost of improvement is estimated by Mr. Williamson at $61,000, including 10 per cent. for contingencies. The estimate provides for the removal of 10,550 cubic yards of rock, of the old wreck and of the pile obstructions, as well as of several thousand snags, all in the fresh-water compartment of the river, and for dredging 8,000 cubic yards of material near to and above Darien. This estimate covers only those points for which the examination furnished approximate data to base a computation upon; those localities where sand-bars occur and which likewise would require improvement are not included, since it will be necessary to have them instrumentally surveyed before a plan of improvement can be devised.

The estimate is therefore incomplete. It must be also remarked that Mr. Williamson appears to assume the width of the channel to be established at 200 feet. Probably a width of 80 to 100 feet would be ample for a number of years, in which case the estimate given would be reduced at least 50 to 60 per cent.

It is thought that the sum of $30,000 might be advantageously expended in improving those portions of the river where the needs and proper methods of improvement are obvious, and in making more careful surveys of several other points concerning which the information gathered by the recent examination is incomplete. It seems likely, as a rough estimate, that the entire cost of the improvement for a channel not less than 80 feet wide, and 3 feet deep at low river, will reach as high as $60,000 for all classes of work.

The statistics collected in regard to the importance of the Altamaha as a commercial route are not as full as desirable. The bulk of the freight carried on it consists of naval stores, timber, and rice. The annual trade in naval stores is estimated at 2,000 barrels of spirits of turpentine and 10,000 barrels of rosin. It is asserted that the forest lands in the vicinity of the Altamaha are the finest in Georgia for the production of turpentine, the amount of which would be quadrupled in one year by a suitable improvement of the river for light-draught boats.

Over 200,000 bushels of rice produced in the tidal districts of the river are annually exported by way of the Altamaha.

Mr. G. W. Faries, general inspector of timber at Darien, states that from 55,000,000 to 70,000,000 feet of square and scab timber reach Darien from the Altamaha annually.

From official statements of the marine and export trade of the port of Darien the following recapitulation is extracted:

EXPORTED.

Period.	Number of vessels.	Aggregate tonnage.	Hewn and sawed timber and lumber.
			Feet.
January 1, 1879, to January 1, 1880	172	81,378	58,252,915
January 1, 1880, to July 1, 1880	165	74,116	55,792,538

All this timber arrives by way of the Altamaha. Mr. Williamson states that a good deal of timber is rafted down that river, which is not included in the above figures as it does not pass through Darien.

Altamaha River is of additional importance when considered as the eastern branch of the proposed Southern transportation route, connecting the Mississippi River at Paducah, by way of the Tennessee and Ocmulgee rivers, with the Atlantic Ocean.

This work is located in the collection district of Brunswick. Darien is the nearest port of entry.

In regard to the amount of revenue collected at Brunswick and Darien from import and tonnage duties, no information later than for the year 1878 was obtained, in which year it amounted to $19,766.57.

The report of Assistant Engineer W. G. Williamson is transmitted herewith.

* * * * * * *

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers.
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF W. G. WILLIAMSON, ASSISTANT ENGINEER.

LEXINGTON, VA., *November* 13, 1880.

GENERAL: I have the honor to submit the following report of the survey of the Altamaha River, Georgia:

We commenced the survey on the 20th of October, and finished on the 30th. This survey like that of the Canoochee might more properly be called an examination, as the time and money allotted to it did not permit of an instrumental survey. Just here it will be in place to add that I consider the Altamaha well worth improving, and also that in order to decide upon the best plan for its improvement an instrumental survey ought to be made. The Altamaha is formed by the junction of the Ocmulgee and Oconee, on the dividing line between the counties of Montgomery on the north and Appling on the south; thence flowing southeast it forms the boundary between Tattnall, Liberty, and McIntosh counties on the northeast, and Appling, Wayne, and Glynn, on the southwest. The length as estimated on our survey, from the junction of the Ocmulgee and Oconee to Darien, the point designated as the terminus of the survey in your instructions, is 155.2 miles. The water was low when our examination was made, being about 1 foot above low-water. The velocity varies from ½ to 2 miles per hour. The fall is so gradual that it was impossible without instruments to determine it. In no case, however, does it amount to enough to retard boats to any great extent. Between the shoals the water varies in depth from 6 to 12 feet or more. In comparison with other rivers now being improved by the general government, and considering its length, the shoals are very few. With the exception of three or four of these shoals, in the fresh-water compartment there is a depth of 3.0 feet and over on all

of them. The most dangerous obstructions are snags, and some rock ledges which run nearly across the stream. The snags and rocks can be easily removed.

The sand-bars will require training walls built in such a manner as to force the current to scour the bed of the stream. These bars present a more difficult problem to the engineer than the rock bars. It is to decide upon a plan for the improvement of these bars that an instrumental survey becomes necessary.

There are sloughs and creeks making from and to the river, about the mouths of which bars form. In many instances these might be shut out by low dams, which would keep the stream within bounds at ordinary water, and at high-tide give such a direction to it as would keep the channel clear.

Timber is so abundant that the engineer might adopt any form of timber dam which local circumstances might suggest as most suitable. Mattresses, facine-dams crib-dams, or pile-dams might be used and would cost very little. In some cases piles driven in quincunx order, with trees and brush firmly fastened between them, would be sufficient to change the direction of a current or prevent its seeking sloughs. The works suggested above are recommended as peculiarly adaptable to the fresh-water compartment of the river. The tidal compartment will require somewhat different treatment, though in some cases the low dams across the mouths of estuaries may be used to advantage. It is impossible for an engineer to consider and advise as to the improvement of such a river unless he is furnished with such data as can be acquired only by accurate surveys and observations of its physical characteristics. Of course it is equally impossible to design improvements without such data.

I will therefore describe the shoals as briefly as I can, giving those characteristics which I was enabled to note on the rapid examination made, and indicate the improvements which struck me as being applicable. I hope you will bear in mind that a more careful and accurate survey might materially modify my suggestions. The distances which will be given are estimated from the junction of the Ocmulgee and Oconee rivers, where the survey commenced.

1. Sand-bar, 1¼ miles; from 3 to 4 feet water at low-water; assuming 3 feet a sufficient depth for boats destinated to navigate the Altamaha, no improvement will be required here.

2. Town Bluff Shoals, 1.6 miles. This shoal consists of a ledge of rocks running S. 34° E., nearly across the river very oblique to the direction of the current. The channel is very narrow. The depth of water at low-water, 2 feet. The velocity about 2 miles per hour. Water in pools above and below varies from 5 to 8 feet. This bar requires a channel to be excavated about 200 feet wide, and may require one or two wing-dams.

3. An old boat sunk 3.4 miles below Dial's Landing should be removed.

4. Sand-bar, 5.4 miles, water 3.3 feet; no work required.

5. Red Bluff, 8.4 miles; ledge of rocks running diagonally across the river; water from 9.5 to 12 feet and over. It is dangerous and should be blasted out. Dials & Collar's mill is situated here; they saw about 4,000,000 feet, board measure, timber per annum.

6. Pine Bluff, 18.69 miles; large rocks dangerously near the channel; depth of water at low-water from 3.7 to 4 feet. Rocks should be removed.

7. Piney Bluff, 19.5 miles; two rock reefs about 1,200 feet apart; 1.5 feet water on the upper one and 3 feet water on the lower one at low-water. Portions of both should be removed. Mann & Melton's saw-mill is situated here on the right bank.

8. Sand-bar, 22 6 miles; over 3 feet water; no work required.

9. Hell's Shoals, 35.8 miles; water from 9 to 12 feet and over; obstruction consists of dangerous sandstone reefs making out from the right bank, and of isolated rocks so situated as to render it almost impossible to avoid them. Some of these should be blown out.

10. Ohoopee White Bluff, 39.7 miles; sand-bar formed by the river spreading over a large area, and the current being checked at times by the water from an adjacent lake. Water 2 feet deep at low-water. Training dams will be required here.

11. Ohoopee Cut, 43.6 miles; water from 5 to 12 feet deep at low-water. A dam should be thrown across the lower end of the old river so as to cause it to fill up and force all the water through the present channel (the cut). It might also be well to trim off the ragged points and straighten the cut.

12. Shoal at Stafford's Ferry, 48.1 miles; water from 2.9 to 3.9 feet at low-water. Training dams needed.

13. Upper Sister Bluff, 49.4 miles; water from 3.6 feet to 3.9 feet at low-water; no work required now.

14. Lower Sister Bluff, 50.7 miles; bar from 3 to 3.5 feet water at low-water, about ⅘ of a mile below the bluff; no work required now.

15. Stooping Gum Cut, 57.6 miles; needs clearing out and straightening.

16. Beard's Creek and Bluff, 62.8 miles; channel filled with snags; water sufficient at present; may in future require training dams.

17. Sand-bar, 67.9 miles; 2.3 to 4.8 water; needs training dam.

18. Sand-bar, 71.2 miles; 3.3 to 5.3 feet water; may require training dam in course of time.

19. Oglethorp Bluff, 72.7 miles; 3.3 to 4.3 feet water; bar needs some excavation; snags should be cleaned out; no work needed at present.

20. Doctortown, 82.9 miles; water from 8 to 12 feet and more; railroad bridge needs draw, being only 36½ feet above the water; two saw-mills there; number of old slabs and binders in the river; mill owners should be required when using rafts to burn binders.

21. Confederate obstructions, 87.8 miles; piles driven in the bed of the river; $1,000 will probably more than cover the expense of removing them; channel way at present clear; water over 12 feet deep.

22. Steamboat Cut, 100 miles; water over 8 feet deep; Old River should be shut out.

23. Confederate obstructions, 105.24 miles; piles driven in the bed of the river partially removed; water from 9 to 12 feet deep: $500 will probably cover the expenses of removing them.

24. Fort Barrington, 124.09 miles; water 3 to 4 feet deep; may require training dams; head of tide.

25. First South River, 142.16 miles; water 2.8 feet; needs training dams shutting out First South River.

26. Second South River, 142.99 miles; water, 7 feet; the river should be shut off, and an old wreck near channel removed.

27. Sand-bar, 146.3 miles; water, 3.6 to 4 feet at low-water; needs examination.

28. Cooper's River, 149.28 miles; bar opposite the mouth of Cooper River; channel navigable for boats drawing 3 feet water, but it needs improvement; judiciously located jetties might answer. It would be well, too, to shut out partially Cooper's River.

29. Wood's Cut, low end, 152.7 miles; bar; at least 3.3 feet water at low-water; needs dredging to widen channel.

30. Bar, 153.22 miles; water, 3 feet or more; channel narrow; needs dredging.

31. Bar, 153.7 miles; water, from 3 to 4 feet; needs dredging to widen the channel.

As I have said before, more accurate surveys must be made before detailed plans of the work can be decided on. In the fresh-water compartment training-dams, preventing the water from running through sloughs or spreading over extended areas, and forcing it into the proper channel, are, in my opinion, better than jetties, because these dams can be built so as to guide the current over and beyond the bars, and of such shapes as to present a comparatively smooth surface to the current, while jetties act locally, causing a scour immediately at their ends and producing currents, counter-currents, and eddies, which in their turn form other bars, sometimes more troublesome than those they were intended to improve.

In the tidal compartment jetties are objectionable, because there the currents running up at flood and down at ebb tide cause bars to form between the jetties, and it would be finally necessary to connect the ends of the jetties in order to form a straight or gently curving channel, depending upon the course of the river at the point where they are used. It would be better, therefore, to build the continuous training dam in the first instance. Except in peculiar situations, I consider them objectionable in narrow rivers; their action in narrow rivers is very different from what it is at the entrance of harbors.

* * * * * *

I will now give a proposed plan of improvement, and an approximate estimate of cost.

The work should be commenced by removing the snags, rock-reefs, and bars which are impassable at low-water. While this work is in progress, a survey, which would furnish data for planning the other improvements suggested in the first part of this report, should be made. While a continuous survey of the river would be more satisfactory, it is not, in my opinion, positively requisite. Surveys embracing each obstruction and extending far enough above and below it to enable one to plan the improvement for it, would be sufficient. I shall therefore only add an approximate estimate of the cost of improvements for which I think I have data sufficiently near the truth.

APPROXIMATE ESTIMATE OF COST OF IMPROVEMENT.

Removing 5,557 snags, at $5	$27,785 00
Removing 550 cubic yards rock excavation, Town Bluff, at $5	2,750 00
Removing 6,000 cubic yards gravel excavation, at 23 cents	1,380 00
Removing old wreck	200 00
Removing 300 cubic yards rock, Red Bluff, at $5	1,500 00
Removing 500 cubic yards rock, Pine Bluff, at $5	2,500 00
Removing 3,000 cubic yards rock, Piney Bluff, at $5	15,000 00
Removing 200 cubic yards rock, Hell's Shoals, at $5	1,000 00
Confederate obstructions	1,000 00

Confederate obstructions	$500 00
Bar, 153.2 miles, 4,000 cubic yards, dredging, at 23 cents	920 00
Bar, 153.7 miles, 4,000 cubic yards, dredging, at 23 cents	920 00
	55,455 00
Superintendence and engineering, 10 per cent	5,545 50
	61,000 50

The above estimate would be sufficient for boats drawing 3 feet, except at extreme low-water, when some of the sand-bars, for the improvement of which no estimate has been made, might stop a boat of that draught.

The Altamaha is in the collection district of Brunswick, Ga. Darien, Ga., is its port of entry. There is a deputy collector at Darien.

Very respectfully, your obedient servant,

W. G. WILLIAMSON,
Assistant Engineer.

General Q. A. GILLMORE,
Lieutenant-Colonel Corps of Engineers, U. S. A.

J 10.

IMPROVEMENT OF BRUNSWICK HARBOR, GEORGIA.

During the fiscal year ending June 30, 1881, operations were carried on in general conformity to the plan of improvement suggested in my report of April 29, 1876.

Previous to the beginning of operations under the present project, an appropriation of $10,000 was made by Congress in 1836, and expended for removing a shoal in the same locality, where improvements are now being made.

The present project comprises the construction of a low jetty projecting from the most easterly point of Buzzard's Island, and located approximately parallel to, and 1,000 feet distant from the opposite shore, for the purpose of contracting the water-way and concentrating the currents. The bottom being quite hard and tough in places, it has been necessary to deepen the channel by dredging. The object of these works is to establish and maintain a ship channel 15 feet deep at mean low-water through the shoal situated about 1 mile below the city of Brunswick, where heretofore there existed a navigable low-water depth of only 9 feet.

The cost of the project is estimated at $73,187.50.

RECAPITULATION OF OPERATIONS PRIOR TO JUNE 30, 1880.

The operations essentially consisted in making a survey of the locality, preparing the working plans, and in beginning work, under an appropriation of $20,000, made by act approved March 3, 1879.

At the close of the fiscal year ending June 30, 1880, the work on the crib-jetty under the contract with John Brady had been of a preparatory character, none of the cribs having then been sunk in place.

Only 1,842 cubic yards of material had been removed by dredging under a contract made on February 28, 1880, with Mr. J. E. Walter, at 13⅞ cents per cubic yard. His progress was very slow, and his dredging apparatus was not strong enough for the tenacious material which he unexpectedly encountered at several points.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

During the first quarter of the past fiscal year nothing was done beyond some abortive attempts on the part of the contractor to sink a few cribs which he could not manage to keep together or hold in place.

The actual work of sinking cribs commenced in October, 1880. It was decided to keep the top of cribs generally several feet below the level of low-water, and after filling up each crib to the top with material, as prescribed in the specifications referred to in my last annual report, to throw upon it additional riprap stone, forming a slope about 1 on 2 on each side, with a rounded ridge about 3 feet below the level of mean low-water. By this disposition a greater length of jetty may be built with an equal amount of money. If necessary, the height of the work may be increased by adding more stone.

On June 30, 1881, a length of about 810 feet of jetty was practically completed, although a few cribs last sunk on the main line of the jetty still required some additional riprap stone. This length includes 35 feet of shore end extending from the low-water line to some distance above the high-water line on Buzzard's Island.

The shore end is formed of a log mattress, 24 feet wide, sunk into the soil, loaded with stone raised up on the center line.

The total number of cribs sunk is thirty-seven, of which fourteen constitute the return face, about 300 feet in length, exclusive of the portion above low-water line. The twenty-three cribs on the main line cover a length of 475 feet.

The width of the cribs ranges from 12 to 15 feet, their length being about 22 feet. Their height above the log grillage on which they stand is generally about 9 feet, and the width of the grillage is 24 feet.

Each crib was filled to the top with dredging material resting on a bottom layer of brush and riprap stone inside the work, and was then finished off with a mound of stone, as already described.

During the past fiscal year 34,160 cubic yards of material was dredged, making a total of 36,002 cubic yards since the beginning of operations.

Thus far the result of the dredging has been the cutting of a rudimentary channel through the shoal portions of the approach to the harbor, varying in depth from 12 to 15 feet at low-water, in width from 20 to 80 feet (one cut to four cuts), and extending in a straight line from a depth of 12½ feet on the inner slope of the shoal to a depth of 14 feet on the outer slope some distance below Brandy Point. The extreme length of the cut is about 4,400 feet.

OPERATIONS CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

With the amount available July 1, 1881, as specified in the money statement, it is proposed to continue work on the jetty, and widen and deepen the channel by dredging.

The crib-work of the main line will be continued under the Brady contract until the sum of about $12,000, out of the first appropriation of $20,000 shall have been expended. It is thought that this will carry the main line to a point about 775 feet from the angle with the return face.

It was the first intention to expend about one-half of the second appropriation in further extending the main line by means of palmetto cribs resting on log platforms, substantially as lately practiced under the modified plan. Proposals for doing this work were called for on

September 13, 1880. Mr. John Brady was found to be the only bidder. His offer was considered too high and was rejected.

A new design, described in the following extract from the specifications, was then adopted:

The jetty will be composed of a double raft, laid in sections not less than 50 feet long, constructed of two layers or platforms of round logs, one above the other, overlaid with riprap stone. The logs of each platform will be placed close together, side by side, at right angles to the line of the jetty. Certain portions of the double raft may, at the option of the engineer in charge, be covered with brush before the riprap stone is put on.

The lower platform of the raft will be built of logs of not less than 12 inches average diameter, nor less than 10 inches in diameter at the small end, firmly bound and held together by five binders. The two outside binders will be not less than 5 inches, and the other binders not less than 9 inches in average diameter. The 9-inch binders and the platform logs will not be notched or flattened at the points of crossing.

The upper layer or platform of logs will be placed, without notching or flattening, upon the three inner binders of the lower platform. This upper platform will be composed of logs of the same average diameter as those used for the lower platform, but they will be 10 feet shorter than the lower logs.

The logs of the upper platform will be firmly held together by two or three binders not less than 5 inches in diameter at the small end, and the upper raft will be firmly lashed or bolted to the lower raft in such safe and secure manner as the engineer in charge shall approve.

All the logs and binders entering into the work will be of old-field pine, or some other cheap variety of pine known to be durable under water.

The brush, wherever used, will be deposited upon the double raft in the form of well-tied, compact bundles, or fascines, placed close together to form a compact mass, and securely lashed or fastened to the logs underneath. The brush will be closely piled up and measured before it is placed on the raft, and will be paid for by the cubic yard.

Unless otherwise directed, the lower raft will be 27 feet wide, composed of logs 27 feet long. The width of the lower raft may vary, at the option of the engineer in charge, from 24 to 34 feet.

Riprap stone, to be sound, dense, of compact form, in pieces varying from 10 pounds upwards in weight, will be placed on the raft to the depth of 1 foot, equal to 1 cubic yard of stone for each running foot of double raft 27 feet wide at the base.

Bids for the work described above were invited by circular letter dated October 30, 1880, but none were received. On May 2, 1881, a contract for this jetty work was entered into with Anderson & Blaisdell at $6.35 per linear foot of double raft, 27 feet wide, overlaid with stone to the depth of 1 foot, and $1 per cubic yard for brush.

The sum of $5,000 appropriated by act of Congress approved March 3, 1881, will also be expended in further extending the jetty. Proposals were called for on May 28, 1881, the specifications being essentially identical with those of October 30, except that the double raft was to be furnished by the square yard, and the broken stone by the cubic yard.

John Brady made the only bid, which was rejected as too high. The Chief of Engineers has authorized new bids to be invited by circular letter, and in the event of none being received advantageous to the United States to do the work by special arrangement.

It is proposed to expend in dredging about $5,000, or one-half the sum appropriated by act approved June 14, 1880, and proposals were invited August 18, 1880. Mr. J. E. Walter, of Savannah, Ga., was the only bidder, at the rate of 24½ cents per cubic yard of sand, or sand and loam mixed, and 33½ cents for compact clay or shell stone. These prices, though high, were not deemed exorbitant under the circumstances, but as he was at that time much behindhand in his former contract, he was informed that no agreement would be made with him unless he was prepared to supply better machinery. His progress has recently been more satisfactory, and a contract will be entered into with him at 27 cents per cubic yard for the hard and soft materials, taken as they come. Operations under this new contract will be commenced at an early day.

Brunswick is a comparatively small, but of late rapidly growing place. with deep and well-sheltered anchorages in front of the city and in Brunswick River. It has an easy entrance from the sea. In 1879 the least depth at ordinary low-water in the bar channel was from 16 to 17 feet, with a mean rise and fall of tides of nearly 7 feet. The principal drawback to the marine commerce of the port consists in the shoal or bar at the mouth of East River, opposite Brandy Point, where works of improvement are now under construction.

The number and aggregate tonnage of vessels arriving and clearing at Brunswick is rapidly increasing. During the year 1880, 678 vessels arrived at or cleared from the port, or 222 more than in 1879, and 282 more than in 1878. The aggregate tonnage in 1880 was 207,771 tons, or 47 per cent. more than in 1879, and 66 per cent. over that of 1878.

The city is directly connected with the interior of Georgia by two railroads, the Macon and Brunswick Railroad and the Brunswick and Albany Railroad. Although these roads beyond their western terminal points have to contend with competing lines carrying merchandise and produce to other points, the freight business during the last year to and from Brunswick has shown a marked increase on both lines.

With regard to the importance of pushing forward the works of improvement at this point, attention is invited to a letter herewith appended from Mr. John T. Collins, collector of the port, which gives interesting and valuable information in a condensed form; also to a letter from Mr. E. W. Cole, president of the East Tennessee, Virginia and Georgia Railroad Company, which will be found in Assistant Engineer S. L. Fremont's report sent herewith.

This improvement is located in the collection district of Brunswick, Ga. Brunswick is the nearest port of entry.

Import duties collected for the last fiscal year, $17,723,24.

For carrying out the present plan of improvement the following appropriations have been made:

By act of Congress approved March 3, 1879	$20,000 00
By act of Congress approved June 14, 1880	10,000 00
By act of Congress approved March 3, 1881	5,000 00
Total	35,000 00
The estimated cost of the improvement is	73,187 50

The following papers accompany this report:

Chart of Brunswick Harbor, showing location and progress of works of improvement, with details of construction.

Report of Mr. S. L. Fremont, assistant engineer.

Letter of Mr. J. T. Collins.

Commercial statistics of the customs district of Brunswick.

Money statement.

July 1, 1880, amount available		$28,408 54
Amount appropriated by act approved March 3, 1881		5,000 00
		$33,408 54
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	9,715 14	
July 1, 1881, outstanding liabilities	3,453 16	
		13,168 30
July 1, 1881, amount available		20,240 24
Amount (estimated) required for completion of existing project		38,187 50
Amount that can be profitably expended in fiscal year ending June 30, 1883		38,187 50

Abstract of proposals for dredging in the harbor of Brunswick, Ga., opened September 7, 1880

No.	Bidders.	For removing and dumping sand, or sand and loam mixed, per cubic yard.	For removing and dumping compact clay, or shell-stone, or marl, per cubic yard.
1	James E. Walter, Savannah, Ga	$0 24½	$0 33½

Action on this proposal postponed, pending prosecution of work under existing contract.

Abstract of proposals for constructing a jetty in the harbor of Brunswick, Ga., opened October 2, 1881.

No.	Bidders.	For furnishing and putting in the work—							
		Palmetto logs, per linear foot.	Pine logs, per linear foot.	Sawed yellow pine timber, per M feet.	Iron work, per pound.	Locust treenails, each.	Stone filling, per cubic yard.	Brush filling, per cubic yard.	Clay filling, per cubic yard.
1	John Brady, Brooklyn, N. Y..	$0 14	$0 10	$18 00	$0 08	$0 22	$3 50	$0 35	$0 30

Rejected.

REPORT OF MR. S. L. FREMONT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Savannah, July 1, 1881.

GENERAL: I have the honor to submit the following report of the progress made in improving the harbor of Brunswick, Ga., during the fiscal year terminating June 30, 1881:

At the close of the last fiscal year no portion of the jetty for the improvement of the channel of approach to the wharves at that place had been constructed. The contractor was engaged upon the palmetto cribs for it, but was making very slow progress.

The manner of construction was fully described in the last annual report, to which reference is made for any information upon that point.

After much delay in preparing the cribs, an attempt was made to sink one into position, but without any preparation to hold it in place until the tie-piles could be driven and the crib received its complete filling material. The required quantity of brush and stone were placed in the crib, which was to be sunk at low-water slack. The crib was satisfactorily placed and had the piles and tie-rods been in place it would necessarily have remained in position until the dredgings and covering-stone were placed to make it a solid wall.

Without any auxiliary aid, such as a temporary superincumbent weight on top of the crib to help its stability against a very strong flood-current until the piles could be driven, it was left to battle against the current with the strength alone of the drift-bolt fastenings into the soft palmetto logs. As might have been anticipated, the crib parted at the level of the brush and stone filling material. As soon as the fact was made known to me, directions were given to spike on vertical binders inside near each angle, and to have the piles in place as soon as possible. These plank or scantling binders would have given sufficient strength to the cribs to hold them together until the filling, piles, and tie-rods were in place.

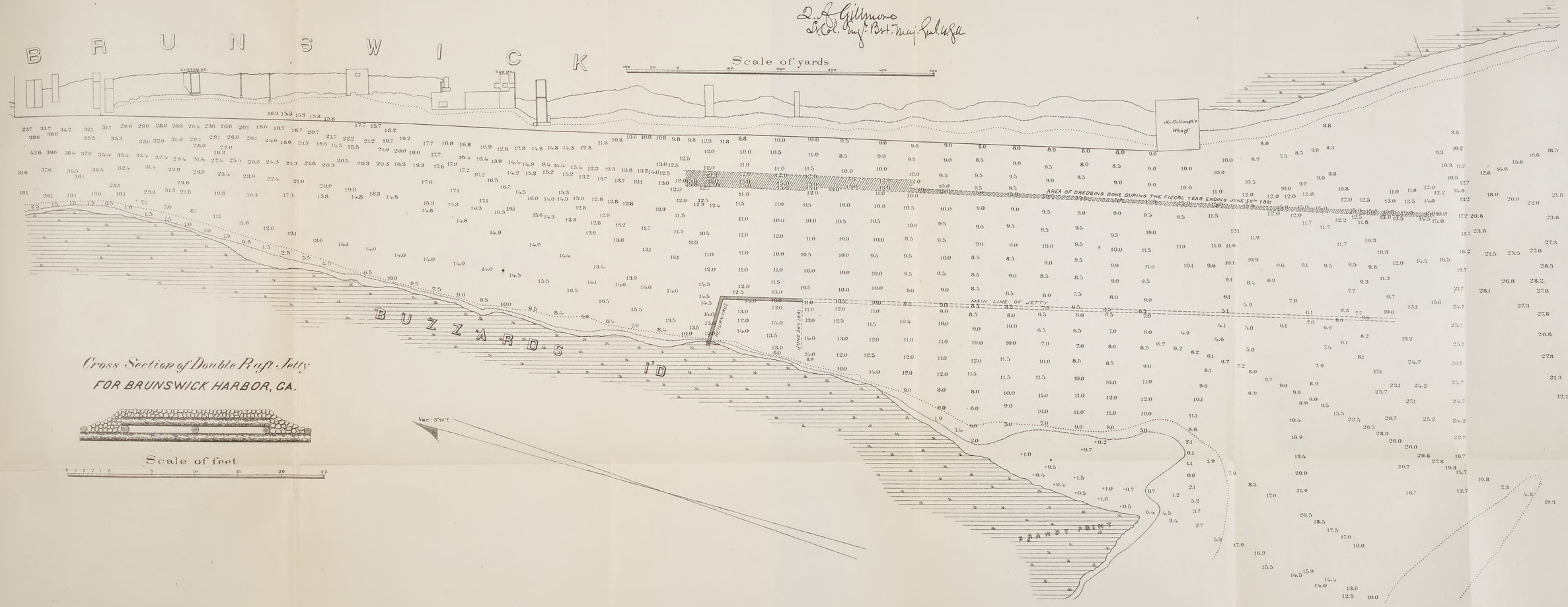
The contractor refused to make the additions required, under a false idea that he


8.9
10.5
12.0

CHART OF BRUNSWICK, GEORGIA

Showing location and progress of work of improvement to June 30th 1881.
Accompanying annual report of July 15th 1881.

D. A. Gillmore
Lt. Col. Engrs. Brt. Maj. Genl. U.S.A.



Cross Section of Double Raft Jetty
FOR BRUNSWICK HARBOR, GA.

Scale of feet

could obtain damages from the government, or a release from his contract with compensation for all of his indifferent work.

Subsequently, by your authority, a modified form of crib was allowed to be used; this crib, when completed, to rise to a height within 3 feet of the low-water line. Since that modification the work has been carried on by the contractor and lately by his attorney, until the return face, 300 feet in length, and about 400 feet of the main line have been completed. This jetty, though not as high as was originally designed, is doing good service as far as it has been completed. The erection of the jetty and the dredging combined have had the effect of increasing the ebb-flow and probably the scour in the channel in front of the city. It is believed that the improvement has already been equal to an increase of about 1 foot in depth, and that the increased velocity of the ebb-flow and the scouring effect on the dredged channel as the work progresses will secure an increased depth throughout the channel.

DREDGING.

The channel that has been dredged in part is about 5,000 feet in length, extending from a depth of 12½ feet of water at the upper end of the harbor to 14 feet in depth at the outlet below Brandy Point.

It is designed with the present appropriation to make this channel 80 feet wide and 14 feet deep at mean low-water. The total amount of material removed during the fiscal year has been 34,160 cubic yards.

THE DOUBLE RAFT JETTY.

With the present appropriation ($10,000) this work will commence at a low-water depth of 10 feet and extend 1,482 feet to a depth of 7 feet, varying as follows:

375 feet of jetty; bottom width, 33 feet; depth, 10 feet water.
296 feet of jetty; bottom width, 30 feet; depth, 9 feet water.
400 feet of jetty; bottom width, 28½ feet; depth, 8½ feet water.
411 feet of jetty; bottom width, 24 feet; depth, 7 feet water.

	Feet.
This gives total length	1,482
Crib jetty, main line and return face	1,073
Total length of jetty	2,555
Original length of jetty, main line	4,300
Which leaves to be provided for on main line	2,045

ESTIMATE FOR COMPLETING WORK.

To complete this work the dredging of a channel 200 feet wide and 6 feet deep will be needed.

This will require 120 feet increase in the width, 5,000 in length, and to a depth of 6 feet, or the removal of 133,333 cubic yards of material, at a cost of 25 cents per yard	$33,333
For extended jetty 2,100 feet, at $7 per linear foot	14,700
Total	48,033

Of this sum $25,000 could be judiciously expended during the next fiscal year.

The several amounts that have been appropriated for the improvement of Brunswick Harbor ar as follows:

In 1879	$20,000
In 1880	10,000
In 1881	5,000
Total	35,000

EXPENDITURES.

Survey of harbor in 1879	$1,000
Cost of crib jetty in 1881	12,500
Dredging, 1880 and 1881	6,500
Contingent expenses, 1880, 1881 (estimate)	2,700
Total (approximate)	22,700
Balance on hand	12,300

The foregoing statement is not designed to show the money on hand at the end of the fiscal year, but at the conclusion of contracts with Messrs. Brady (for the jetty) and Walter (for dredging).

THE FUTURE PROSPECTS AND IMPORTANCE OF BRUNSWICK AS A PORT FOR THE TRANSSHIPMENT OF PRODUCE AND IMPORTED MERCHANDISE FROM AND TO THE WESTERN AND SOUTHWESTERN STATES.

The annexed letter from President E. W. Cole, of the East Tennessee, Virginia and Georgia Railroads, with their purchased and leased lines, will serve to illustrate somewhat this subject. It is a large railway combination.

The line of railway commencing at Brunswick and running west to Macon, Atlanta, and Rome, Ga., where it connects with a system of railways 1,000 miles in extent, controlled by the owners of the Brunswick main stem, alone assures to this port a very large future business.

With the mutually interested connection that it is able to make at Rome and other points with the railway lines of this country, it must bring to Brunswick a vast trade, and surely build up its commercial importance. As a place of transshipment for an area of our western country, it will only be second to Savannah.

In addition to this feeder from the west, there is the railroad from Brunswick to Albany, which has been several years in operation. It has recently been purchased by foreign capitalists, who are about to complete the connection with the Vicksburg, Shreveport, and Pacific Railway.

This will put Brunswick in direct connection with the Southern Pacific railway lines, and these improvements contemplated make this a desirable transshipping point. Its future importance is not only assured, but the near future will witness this consummation.

I am, very respectfully, your obedient servant,

S. L. FREMONT,
Assistant Engineer.

General Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, U. S. A.

LETTER OF PRESIDENT OF EAST TENNESSEE, VIRGINIA AND GEORGIA RAILROAD COMPANY, ETC.

OFFICE OF EAST TENNESSEE, VIRGINIA AND
GEORGIA RAILROAD COMPANY, AND MEMPHIS AND
CHARLESTON RAILROAD LEASED LINE,
Chattanooga, Tenn., June 20, 1881.

MY DEAR SIR: On my return to Chattanooga, I am in receipt of your esteemed favor of the 9th instant.

Brunswick must be an important harbor, and ought to be favored liberally by the government in the expenditure of money in its improvement. Our Macon and Brunswick Railroad extended from Macon to Atlanta and from Atlanta to Rome will connect with a system of about 1,000 miles of other roads that we control, besides perfect connection with roads we do not control, to Cincinnati, Chicago, and Saint Louis. No one is more competent than yourself to take up these lines and the sections tapped by all of our connections, and estimate the importance of the improvement to be made by the government at Brunswick. I trust you may get a large appropriation from the government for this work.

Your friend, most truly,

E. W. COLE,
President.

Col. S. L. FREMONT,
Assistant Engineer.

LETTER OF MR. JOHN T. COLLINS.

CUSTOM-HOUSE, BRUNSWICK, GA.,
Collector's Office, June 24, 1881.

DEAR SIR: In compliance with your request, I herein present a report of the business transacted at the port of Brunswick, Ga., during the year 1880.

It will be seen by reference to the report of transactions through the custom-house that there were over 600 vessels arrived and cleared in the foreign and coastwise trade to and from Brunswick in the year 1880, and the value of the exports shipped on those vessels amounted to $1,702,000, and consisted of lumber, naval stores, wool, rice, and sundry provisions, that being an increase of $500,000 over the previous year, and for the past six months there is shown an increase over the first six months of 1880 of nearly 25 per cent., and the prospect for the next six months promises at least the same result.

Brunswick is one of the most, if not the most, accessible ports on the South Atlantic coast, for, while there are one or two others with more water on the bar, the entrances to those ports are long and tortuous, while the entrance to Brunswick is straight and the bar a short one. There are two railroads terminating at Brunswick: one, the Brunswick and Albany, leading to Albany, Ga.; the other, the Macon and Brunswick, leading to Macon, Ga., where it connects with other lines to the north and west. The business of the above roads has necessarily been limited, as they were confined to a small section of the country, both having to depend on competing lines to secure transportation beyond Albany and Macon. Notwithstanding this fact, however, the business of both roads has increased greatly in the past year. During the year 1880, the Macon and Brunswick road has transported from Brunswick freight amounting to 86,160,851 pounds, and to Brunswick 8,403,220 pounds, aggregating 94,564,071 pounds, that being an increase of about 20 per cent. over the year 1879, and during the months of the present year the increased business over the same time in 1880 promises an increase of at least 25 per cent.

The above road has recently passed into the hands of a company composed of capitalists and experienced railroad managers, which company has already in its possession several lines of road to the west and north, and they have already commenced to build a connecting line between Macon and Atlanta, which will open up to Brunswick a continuous line of road to the west, and all under one management.

BRUNSWICK AND ALBANY RAILROAD.

This road during the year 1880 transported to Brunswick 109,576,960 pounds of freight, and from Brunswick 37,833,440 pounds, an aggregate of 147,410,400 pounds, which was an increase over the year 1879 of nearly 33 per cent., and the business of the present year promises thus far an increase of 50 per cent. over 1880. This road has also changed hands recently, and will soon be connected with a line of road extending through Alabama, and thence through Tennessee and Kentucky, to the northwest. There is no doubt that Brunswick will shortly become one of the most important shipping ports and commercial centers of the South, and for which she has ample facilities.

There is a work in progress at Brunswick, under the supervision of the government, which should be pushed to a speedy completion, and that is the work of clearing out what is known as the Brandy Point Spit. The work already done has benefited the harbor very much, but Congress should make an appropriation large enough to complete the work recommended by you in your report to the Chief of Engineers, as early as possible, and thereby save to commerce thousands of dollars annually which are expended in lighterage and lost through detention owing to the existence of the sand spit referred to, which prevents vessels drawing over 16½ feet from loading to their full capacity before crossing such spit. The inevitable result of the extension of the railroads referred to will be to increase the business of this port tenfold within the next two years, and the loss to commence through the drawback above referred to will, as a matter of course, be increased in proportion, unless Congress by a liberal appropriation has the difficulty removed.

Very respectfully, your obedient servant,

JOHN T. COLLINS.

General Q. A. GILLMORE.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Brunswick, Ga., from January, 1878, to December 31, 1880.

VESSELS ARRIVED.

Years:	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1878.....	116	32,584	850	36	10,218	270	41	19,008	493	193	61,810	1,613
1879.....	148	44,397	1,090	33	8,235	232	40	17,589	468	221	70,221	1,790
1880.....	271	77,656	1,892	36	11,219	317	39	14,996	432	346	103,871	2,641

Arrivals and clearances of vessels at Brunswick, Ga., &c.—Continued.

VESSELS CLEARED.

Years.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1878.....	124	32,767	874	28	9,231	236	49	21,268	550	201	63,266	1,660
1879.....	157	42,345	1,116	21	7,172	172	47	21,730	555	225	71,247	1,843
1880.....	270	78,913	2,010	14	5,010	115	48	19,977	550	332	103,900	2,675

Years.	Value of exports.	Value of imports.	Total collections.
1878	$1,372,842	$400	$4,560 97
1879	1,394,401	3,197	5,644 33
1880	1,702,570	8,908	17,723 24

JOHN T. COLLINS,
Collector.

J 11.

IMPROVEMENT OF ENTRANCE TO CUMBERLAND SOUND, FLORIDA AND GEORGIA.

By act approved June 14, 1880, the sum of $30,000 was appropriated for improving the entrance to Cumberland Sound, between Amelia and Cumberland islands, in the States of Florida and Georgia, which was the first provision made by Congress for improving this entrance.

By act approved March 3, 1881, an additional appropriation of $100,000 was made for the same purpose.

The plan of improvement quite recently began is described in general terms in my report of June 30, 1879, contained in Appendix I 8, Annual Report of the Chief of Engineers for 1879.

The project consists essentially of two low jetties composed of riprap stone resting on a foundation mattress of logs, or logs and brush, starting from the shores on opposite sides of the entrance, and extending seaward across the bar, upon lines so directed that the outer ends will be parallel to each other, and from 3,000 to 3,500 feet apart, or such distance as may hereafter be adopted.

If two low jetties reaching across the bar are built, they would be expected to maintain a low-water channel not less than 20 to 21 feet deep. Greater depth could be secured by carrying the jetties to higher levels.

The estimated cost of the work is $2,071,023. With a single long jetty, placed on the north shoal, and a spur jetty on the south side, a low-water channel 16 to 17 feet deep would be maintained.

The work in this case would cost about $1,000,000.

OPERATION DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

To expend the first appropriation of $30,000 proposals were invited August 3, 1880, for beginning work on the north jetty, which will be composed of a superstructure of riprap stone, resting upon a wide foundation mattress, formed mainly of logs, or of logs and brush combined.

The contractor might choose either one of three designs of mattresses given in the specifications. The designs were identical with those de-

scribed in the specifications of August 19, 1880, for the Charleston jetties.

The proposals were to be based upon a compact mattress, or apron, 54 one of the designs referred to, and overlaid with riprap stone to the feet wide and 19 inches thick, constructed in conformity to either depth of 1 foot.

Bids were also invited for furnishing, and placing upon the apron, by the cubic yard, such additional amount of stone, not exceeding 5,000 cubic yards, as might be required.

Of three bids received, one made by Messrs. A. L. Lara, of Staunton, Va., R. G. Ross, of Wilmington, N. C., and F. P. Murphy, of Washington, D. C., doing business under the firm name of Lara, Ross & Co., was the lowest, and the contract was awarded to them on September 4, 1880. To the same parties a contract had been given for commencing work on the jetties at the mouth of the Saint John's River, and it was understood that they would make such arrangements as would enable them to begin operations simultaneously at both places, but they encountered so many delays and difficulties in bringing together their plant and material for the Saint John's River work, that they were allowed to appoint Blaisdell & Greeley their agents to carry on the Cumberland Sound work.

For a considerable length of time these parties were also delayed by the rough spring weather, and had to confine themselves to the collection of the necessary plant and material; and the first mats were not laid until June, 1881.

The land end of the north jetty is located on the east shore, and about 2,000 feet from the southern extremity of Cumberland Island.

The work has been started on a range bearing about south 63½° east, and this direction was followed in crossing Cumberland Channel, and until the shoal water east of it is reached.

Up to June 30, 1881, the aggregate length of apron foundation laid was 276 feet, from 25 to 35 feet in width, composed of a mattress of log and brush about 19 inches thick, overlaid with riprap stone to an average thickness of about 1¼ feet in the work.

OPERATIONS CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

With the unexpended balance of the two appropriations, it is proposed to continue work on the north jetty, and perhaps begin the construction of the south jetty, by methods substantially the same as that now in use.

Proposals were invited April 16, 1881, for expending the sum last appropriated.

The work will consist substantially in laying upon the bottom, or upon work previously laid, wherever required on either jetty, one or more courses, composed of a mattress overlaid with stone.

The contractor may choose either of two designs, given in the specifications, which are identical with those described in the specifications of the same date for the Charleston jetties.

The bidders were required to name a price in the work for mattresses by the square yard, and for riprap stone by the cubic yard. Of the bids received, and opened on May 10, 1881, one made by Mr. J. Brady, of Brooklyn, N. Y., was the lowest. The acceptance of his bid could not be recommended, and, with the approval of the Chief of Engineers, the contract will be awarded to A. Blaisdell, the next lowest bidder.

No final agreement will be made with him, however, unless he shows good progress on the north jetty, recently begun.

The eastern shore of Cumberland Island, in the vicinity of the north jetty, has receded to some extent during the last few years, and spring tides have at several points occasionally swept across the island to the creek on the west side.

At the point where the north jetty will cross Cumberland Channel, the maximum low-water depth is now 12½ feet, an increase of about 2 feet within the last two years, and the deepest line of channel is now much nearer to the low-water line of the island than formerly.

The shoals bounding Amelia Basin and the channel have remained practically stationary as far out as about 1 mile east of Amelia Island. On the bar proper, the north channel is still moving to the southward, and has now the best water, while the more southern branch is growing shoaler.

This movement was anticipated, and the probability of its occurrence set forth in my report on the improvement of the entrance to Cumberland Sound, dated April 15, 1876.

Fernandina is by nature the most favored harbor on the Atlantic coast of Florida. The usual available depth on the bar is 13 feet, although sometimes not more than 11½ feet, at average low-tide, with an ordinary rise and fall of tides of about 6 feet.

Inside the bar, the anchorage is very capacious, deep, and well sheltered. The entrance is defended by the guns of Fort Clinch.

Vessels having passed over the bar may proceed either to Fernandina or Saint Mary's.

The wharves of Fernandina, on Amelia River, are about 6 statute miles from the bar; those of Saint Mary's, about 10½ miles distant, are reached through the Saint Mary's River. At a distance of 20 miles above Saint Mary's, the water is entirely fresh, and the importance of this locality as a rendezvous for iron-clads and other iron-hulled vessels, where they will be free from barnacles, and from the corroding effects of salt water, and where they can be supplied with good drinking water, has often been officially pointed out.

During the last year the arrivals at Fernandina and Saint Mary's, over the bar, including coastwise vessels not recorded at the custom houses, amounted to 547 vessels, of an aggregate tonnage of 300,642 tons. Lumber to the amount of nearly 50,000,000 feet was shipped during the year, about one-third of which went to foreign countries. The shipments of naval stores and cotton seed were also large. It is claimed that four-fifths of the early vegetables raised in Florida, and sent to northern markets, pass through Fernandina.

Fernandina is connected with Brunswick and Savannah through the inland water route, by a daily line of steamers. Steamers also run regularly between Fernandina and Charleston, Nassau and New York, and it is said that a transatlantic steam line has been organized.

This port is well situated for the lumber business. Many saw-mills exist on the Saint Mary's River. Persons able to form a good judgment in such matters, assert that the best yellow pine timber land of the Southern States is found in the central portion of the peninsula of Florida, extending south to Hernando County, and north into Southern Georgia.

The Atlantic, Gulf and West India Transit Railroad, from Fernandina to Cedar Keys, 155 miles long, traverses this timber region from northeast to southwest.

Several large saw-mills have been constructed on this line, and others are building.

The Peninsular Railroad, 51 miles long, branching off from the Atlantic, Gulf to the West India road at Waldo, runs southward to Ocala, and it is proposed to extend it to Tampa and Charlotte Harbor.

This road when completed will pass through the best timber land in a north and south direction.

From Cedar Keys easy access is had by water to the pine lands of Northern and Middle Florida, by the Suwannee, Wacissa, Saint Mark's, Ocklockony and other rivers, all of which are, or can be made, tributary to the railroad running to Fernandina.

The existing connection by rail with Orange Lake, by way of the Peninsular Railroad, is expected to open up a fruit trade of great magnitude. On the shores of this lake are believed to be the most extensive orange groves of the world.

Hon. D. L. Yulee, in an address to the Fernandina Board of Trade, last year, stated the number of orange trees there growing, and actually counted, either bearing, or soon coming into bearing, to be over half a million, with a capacity to yield about 500,000,000 of oranges a year, equal to 3,000,000 crates, most, if not all of which, would go by rail to Fernandina.

This work is located in two collection districts, the north jetty being in the collection district of Saint Mary's, Ga., and the south jetty in that of Fernandina, Fla. Fernandina is the nearest port of entry.

Import duties collected in 1880	$7,808 00
Estimate cost of the works	2,071,023 00

The following appropriations have been made:

By act of Congress approved June 14, 1880	$30,000 00
By act of Congress approved March 3, 1881	100,000 00
Total	130,000 00

The following papers accompany this report:

Report of First Lieut. W. L. Fisk, Corps of Engineers.
Table of commercial statistics furnished by the collector at Fernandina.

Money statement.

July 1, 1880, amount available	$30,000 00	
Amount appropriated by act approved March 3, 1881	100,000 00	
		$130,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		1,077 02
July 1, 1881, amount available		128,922 98
Amount (estimated) required for completion of existing project		1,941,023 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		500,000 00

Abstract of proposals for constructing jetties at the entrance to Cumberland Sound, Florida and Georgia, opened August 31, 1880.

No.	Names of bidders.	Per linear foot of mattress 54 feet wide, overlaid with riprap stone 1 foot thick.			For riprap stone of 2,800 pounds to the cubic yard.
		First design.	Second design.	Third design.	
					Per cu. yd.
1	Aaron S. Lara, of Staunton, Va.; Roderick G. Ross, of Wilmington, N. C.; and Frank P. Murphy, of Washington, D. C.	$12 34	$12 49	$11 59	$3 34
2	John F. Gaynor, of Fayetteville, N. Y	16 40	16 40	16 40	4 50
3	John Brady, of Brooklyn, N. Y	14 35	14 35	14 35	3 50

Abstract of contract for constructing jetties at entrance to Cumberland Sound, Florida and Georgia.

Contractors.	Residence.	Date of contract.	Nature of work.	To be complete.
Lara, Ross & Co...	Staunton, Va	Sept. 4, 1880	Constructing jetties at entrance to Cumberland Sound, under second design, and furnishing riprap stone, at prices stated.	June 30, 1881

Abstract of proposals for continuing construction of jetties at entrance to Cumberland Sound, Florida and Georgia, opened May 10, 1881.

No.	Names of bidders.	Mattresses.	Riprap stone, 2,700 pounds to the cubic yard.	Remarks.
		Per sq. yd.	*Per cb. yd.*	
1	John Brady, Brooklyn, N. Y.....	$0 68	$3 50	Proposal rejected by authority of the Chief of Engineers.
2	John F. Gaynor, Fayetteville, N. Y.....	90	4 50	
3	Albert Blaisdell, Jacksonville, Fla	98	3 75	Contract to be awarded.

REPORT OF LIEUTENANT W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., July 1, 1881.

SIR: I have to submit the following report upon the work for the improvement of the entrance to Cumberland Sound, Georgia and Florida, for the year ending June 30, 1881.

All work done has been on the north jetty, springing from the east side of Cumberland Island, Georgia, at a point about 2,000 feet from its southern extremity.

The mattresses used in this work are like those used at the mouth of the Saint John's River, except that instead of the layer of brush the spaces between the binders are filled with slabs.

The first mat was set on range 1, on the 8th of June, is 50 feet long by 35 feet wide, and was floated in shore and sunk on the top of a high tide.

Work was then begun at high-water mark, and carried outward as described for similar work on Saint John's Bar.

This part of the jetty is 25 feet wide. One mat, 30 feet long, is to connect it with the 35-foot mat first sunk, outside of which the mats are floated into position. Two hundred and seventy-six feet of mats have been laid and completed to and including June 30, 1881.

The north jetty is in the collection district of Saint Mary's, and the south jetty in that of Fernandina; Saint Mary's, Ga., and Fernandina, Fla., being the respective ports of entry, and the latter nearest the work.

Very respectfully, your obedient servant,

W. L. FISK,
First Lieutenant of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, Bvt. Brig. Gen., U. S. A.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Fernandina, Fla., from January 1, 1877, *to December* 31, 1880.

VESSELS ARRIVED.

Years.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1877.....	150	100, 581	3, 343	32	8, 088	217	40	12, 541	404	222	122, 200	3, 782
1878.....	185	120, 865	3, 909	16	3, 985	101	42	8, 294	215	223	133, 144	4, 225
1879.....	199	133, 309	4, 138	28	9, 634	252	10	5, 645	126	237	148, 588	4, 516
1880.....	260	156, 740	4, 470	34	22, 396	598	22	9, 463	240	316	188, 599	5, 308

VESSELS CLEARED.

Years.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1877.....	165	106, 638	3, 590	24	6, 340	166	42	13, 641	412	231	126, 619	4, 168
1878.....	195	124, 883	4, 086	19	4, 911	123	25	9, 080	236	239	138, 874	4, 445
1879.....	205	129, 650	4, 079	31	11, 066	258	12	8, 026	164	248	148, 742	4, 501
1880.....	246	155, 649	4, 505	31	14, 161	327	24	10, 202	240	301	180, 012	5, 072

Years.	Value of exports.	Value of imports.	Duties collected.
1877	$315, 446	$19. 639	$2, 376
1878	258, 184	11, 862	2, 090
1879	283, 476	11, 047	3, 424
1880	259, 514	15, 679	7, 808

JOHN W. HOWELL,
Collector of Customs.

J 12.

IMPROVEMENT OF INSIDE PASSAGE BETWEEN FERNANDINA AND SAINT JOHN'S RIVER, FLORIDA.

By act approved June 14, 1880, the sum of $7,000 was appropriated for continuing the improvement of this passage.

Appropriations for its improvement were made at various times from 1828 to 1838, aggregating $78,000, chiefly expended in dredging out Kingsley's Cut, in Amelia River, 3 or 4 miles south of Fernandina, and Gunnison's Cut, in Saw Pit Creek, 4½ miles south of Nassau Sound.

No further appropriations were made until the year 1874.

By act approved June 23, 1874, the sum of $10,000 was appropriated, of which $2,627.60 was employed in making a thorough survey of that part of the route south of Nassau Inlet, about 14 miles in length, except 3½ miles on the northern end of it. The balance of the appropriation

was expended during the fiscal year ending June 30, 1876, in dredging at various shoals between Nassau Sound and Saint John's River. It resulted in a cut being made 4 feet deep and 40 feet wide, at mean low-water, giving a flood-tide channel of 9 feet depth over the worst shoals.

The next appropriation was made in 1879, amounting to $7,000.

Dredging was done at the confluence of Sister's Creek with Saint John's River, at Cow Bank, Ocmulgee Point, Deep-water Point, and Gunnison's Cut. There was thereby secured over these shoals a low-water depth of not less than 5 feet, with widths varying from 25 to 60 feet.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

It was the intention to expend the last appropriation of $7,000 in enlarging the existing channel by dredging at those points on the shoals where increased channel-way was most needed.

Proposals were accordingly invited October 26, 1880, but no formal bid was obtained.

An offer was made by J. A. Cloud, of Jacksonville, Fla., to do the work, as it run, at 30 cents per cubic yard. He subsequently reduced the price to 26 cents per cubic yard of material deposited on the banks, and an agreement was made with him upon this basis.

Dredging began on October 11 and was suspended on December 1 following.

The work was confined to Gunnison's Cut, where a low-water channel of 5 feet depth had been cut during the preceding year, but where, on examination made in the beginning of October, 1880, less than 2 feet was found. This shoaling commenced at the northern end of Gunnison's Cut, and extended quite uniformly through it for a length of about 2,300 feet.

When work stopped, a single cut of the dredge to a low-water depth of 5 feet had been carried a distance of 2,057 feet, along the east side of Gunnison's Cut. A total of 8,684$\frac{3}{4}$ cubic yards had been taken out and deposited from the bucket above high-water mark.

The work has not since been resumed, for the reasons that there seemed to be not only no urgent need for its continuance, but no prospect of securing any permanent benefit from the expenditure of small appropriations.

The recently shortened railroad lines from Fernandina to Jacksonville, and Fernandina to Savannah, will undoubtedly lessen the value of this inland water route. After the bar at the mouth of Saint John's River, and that river itself as far as Jacksonville, have been improved, passengers and freight between Jacksonville, Fernandina, and Savannah will have a choice between transit by rail, on a moderately quick schedule, and transit by sea and river by coasting steamers.

Still the inside passage between Savannah and Jacksonville, which actually continues far into the interior of Florida, by means of the Saint John's River, may be considered as a valuable water-route for many purposes.

Its importance in the case of the United States becoming involved in war with a maritime power, has been repeatedly pointed out in former reports. Its improvement, when undertaken, should be on a liberal scale.

This inland route is partly in the collection district of Fernandina and partly in that of Saint John's, of which Fernandina and Jacksonville are the respective ports of entry.

The report of Lieut. W. L. Fisk, Corps of Engineers, is appended.

Money statement.

July 1, 1880, amount available	$7,007 62
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	2,570 11
July 1, 1881, amount available	4,437 51

REPORT OF LIEUTENANT W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., June 23, 1881.

SIR: I have the honor to submit the following report of work done on the inside passage between the Saint John's River and Fernandina Fla., during the year 1880–'81.

The work, consisting entirely of dredging, was confined to that part of the passage between Nassau Inlet and the Saint John's River.

A hasty examination before commencing work showed the shoalest part of the channel to be Gunnison's Cut, in Saw Pit Creek, where there was less than 2 feet depth at low-water (7 feet at high-water), with a width of, say, 75 feet, and where a channel 5 feet deep (low-water) and 50 feet wide had been dredged during the year 1879–'80. This shoaling, beginning at the northern end of Gunnison's Cut, had taken place quite uniformly through a portion of it, something over 2,300 feet in length. The contractor was therefore directed to begin at the north end of this cut, and excavate to a depth of 5 feet at low-water, the channel to be of the width of two cuts of the dredge, or about 55 feet.

Work was commenced on October 15, 1880, and continued until November 30, when it was suspended.

Much time was lost by several breakages of the machinery and an attempt to use salt water in the boilers of the dredge; some delay was caused by the necessity of removing the dredge every time a boat passed.

When work stopped, a single cut of the dredge to the low-water depth of 5 feet had been carried a distance of 2,057 feet along the east side of Gunnison's Cut, a total of 8,684¾ cubic yards having been excavated and deposited from the bucket above high-water mark.

Until about February 1, 1881, the steamer Florida, running from Savannah, Ga., to Jacksonville and Palatka, Fla., made two round trips weekly through the passage, and since that time I do not think a half dozen boats, all told, have used the route, all freight and passengers reaching Jacksonville by the new short line of railroad from Fernandina.

No work has been done since November 30, 1880.

This work is partly in the collection district of Fernandina, and partly in that of Saint John's, of which Fernandina and Jacksonville are the respective ports of entry.

Very respectfully, your obedient servant,

W. L. FISK,
First Lieutenant of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, Bvt. Maj. Gen., U. S. A.

J 13.

IMPROVEMENT OF THE SAINT JOHN'S RIVER, FLORIDA.

The work done during the last fiscal year consisted in commencing the new project of improving the channel over the bar at the mouth of the river by means of two jetties, submitted in my communication to the Chief of Engineers, dated June 30, 1879.

The sum of $125,000 had been appropriated by act approved June 14, 1880, for beginning operations. This was the first appropriation made for constructing works intended to permanently improve the ship channel through the bar.

Previously an aggregate sum of $57,476.28 had been expended here

in dredging, for the temporary improvement of the channel, since the close of the civil war.

For making the preliminary survey, and preparing the project, the sum of $2,523.74 was expended.

OPERATIONS DURING THE FISCAL YEAR CLOSING JUNE 30, 1881.

On August 3, 1880, proposals were invited for beginning the work of constructing the jetties at the mouth of the river, by laying a foundation apron built principally of logs and stone, or of logs, brush, and stone, at the option of the bidder, who might select either one of the three designs described in the specifications. The designs were the same as those given in the specifications for work on the Charleston jetties, dated August 19, 1880, and the necessary explanation in regard to them is found in my annual report on the improvement of the harbor of Charleston for the year ending June 30, 1881.

The proposals were to be based on a compact mattress of 54 feet width and 19 inches thick, covered with stone to a depth of 1 foot, and upon furnishing and placing on the work such additional stone, not exceeding 5,000 cubic yards, as might be required.

The lowest bid was made by Messrs. A. L. Lara, of Staunton, Va., R. G. Ross, of Wilmington, N. C., and F. P. Murphy, of Washington, D. C., and the contract was awarded to them on September 4, 1880, under the firm name of Lara, Ross & Company.

It was decided to commence the south jetty first, and to lay its apron for a moderate length before starting the north jetty.

The position selected is shown on the chart accompanying this report.

The apron has thus far been built upon dredges. The shore range begins at high-water line and extends about 874 feet in a direction north 46° 45′ east, reaching a short distance beyond the low-water mark.

About 800 feet from the starting point on shore the main line begins, forming an angle of 28° 09′ with a shore range, thus leaving about 70 feet in length of the shore range projecting as a spur beyond the shoulder angle. This second range bears north 74° 54′ east. By this disposition of the main line the shallow waters of Pelican Shoal are avoided, and left south of the jetty.

The contractors were delayed in beginning work by the difficulty of hauling timber from the woods, which were flooded by the heavy rains in October and November.

The first mattresses were laid in the latter part of December. Until February the progress was slow, owing, in a great measure, to unfavorable weather, but since then the work has gone on more rapidly. On June 30, 1881, the total length of apron laid was 2,786 feet, of which about 1,912 feet were on the main line of jetty.

On the shore range the width of mats varied from 20 to 36 feet, the thickness from 16 to 20 inches, and the thickness of mattress and stone from 2½ to 3 feet.

On the main line the width of the mats ranged from 38 to 87 feet, the thickness from 19 to 21 inches, and the thickness of mattress and stone from 2 feet 10 inches to 3 feet.

The stone thus used amounted to 6,029 cubic yards. No stone was received by the cubic yard.

At the close of the fiscal year the outer end of the apron rested in water about 20 feet deep at low-tide. The greatest depth met with in crossing the south channel was 22.8 feet, at a distance of about 550 feet from the point of junction with the shore range.

No work was done on the north jetty during the last fiscal year.

THE CONDITION OF THE WORK.

As far as could be observed the work is in perfectly good condition. Soundings made a few weeks ago over the apron of the main line proved that no stone was exposed, the depth of water along the crest of the work having diminished at several points as much as 1 foot since the work was put down. This shows that an accumulation of sand has taken place, completely covering up mattresses and stone. The local engineer in charge is even inclined to think that some building up of sand occurs in advance of the work, as this peculiar action was noticed at the lower end of the shore range of the apron, where a single tide sometimes caused a piling up of sand about 1 foot high.

If this accumulation of sand on top of the work continues it will be of material assistance to protect the logs and brush of the mats from the teredo and to some extent lessen the cost of construction.

EFFECTS OF THE WORK AND CHANGES GENERALLY.

The work has not yet attained that stage when any changes that have occurred on the bar may be unmistakably ascribed to its influence. Lieutenant Fisk, in immediate charge of the work, thinks that the only noticeable effect of the jetty so far is that it seems to have checked the advance of the shoal on the north side of the north channel, and to be gradually washing off the point of it.

The north channel, which had gradually worked to the southward and shoaled up since the survey of 1878, is again moving toward the position it occupied in 1853 and in 1878, and the buoys which had been removed were replaced a short time ago. Its present location is shown, approximately, on the chart accompanying this report.

The south channel is still almost exclusively used by vessels, because it is shorter than the north channel. There is little difference in depth of water between the two. There is no danger as yet of the work interfering with the navigation of this channel. No vessels come here that draw over 12½ feet of water, and they always cross the jetty at or near the high-water stage, when they find a depth of over 22 feet over the work. The jetty may receive fully 6 feet additional height without obstructing navigation.

The north shoal has gradually shifted its position since 1878. The outline of the present shoal seen on the chart shows that portion of it which is covered with water at half tide.

Pelican Bank has moved to the southward, and is now about 1,000 feet south of the position it occupied in 1878. A portion of the shoal remains dry at high-water.

Immediately adjoining the south jetty the low-water line has somewhat advanced since work was begun, while the high-water line has remained about stationary.

On that portion of the east shore of Fort George Island where the north jetty will begin, the general surface of the land in rear of the ordinary high-water line has become somewhat lower for a distance of several hundred feet, and a considerable portion of that distance is usually overflowed at high-water of spring-tides. This will perhaps require the shore-end of the jetty to be started further inland than was originally thought to be necessary.

OPERATIONS CONTEMPLATED DURING THE FISCAL YEAR ENDING JUNE 30, 1882.

During the fiscal year just commenced it is proposed to extend the south jetty seaward, to raise it higher where it crosses deep-water, and to begin the north jetty, the work on both jetties to consist mainly as heretofore in mattresses overlaid with riprap stone.

The sum of $100,000 having been appropriated by act approved March 3, 1881, proposals were invited on April 16, 1881, for expending this sum by laying upon the bottom, or upon work already laid, one or more courses composed of a mattress overlaid with stone. Two designs were described in detail in the specifications, either one of which might be used at the option of the contractor. These designs were precisely the same as those described in the specifications of the same date for work on the Charleston jetties, which have been referred to in my report of operations at that place for the past fiscal year.

Bids were opened on May 10, 1881, and one made by Mr. John Brady was the lowest. But, in view of his failure to comply with the requirements of a small contract made with him January 30, 1880, for some crib work in Brunswick Harbor, Georgia, his bid was rejected, and the contract was awarded to Mr. J. H. Durkee, of Jacksonville, Fla., the next lowest bidder. Under the terms of this contract, made June 10, Mr. Durkee will furnish and put in place mattresses at the price of 60 cents per square yard, and stone at $4 per cubic yard of 2,700 pounds. It is expected that he will soon begin work.

During the present fiscal year work will therefore be carried on under two contracts, viz, the one last named and that previously made with Lara, Ross & Co.

Jacksonville is the sea-port of Saint John's River, and is situated about 24 miles from its mouth. The anchorage in front of the city is deep and capacious.

During the last year 383 vessels of 165,731 total tonnage arrived, and 418 vessels of 170,975 tonnage cleared at this port.

By far the larger portion of this maritime business consisted of coastwise trade, the foreign commerce being insignificant.

The great obstacle to the development of the commerce of this port is, and always has been, the shallow and dangerous navigation which characterizes this bar. Vessels are often detained many days, and even weeks, inside, waiting for favorable tides. From a statement received, and believed to be trustworthy, it appears that 409 vessels of 174,214 aggregate tonnage, which left the port during the year ending April 30, 1881, suffered an aggregate detention of 1,914 days, inflicting a very serious loss on both vessel-owners and shippers.

There are other losses due to the bad condition of the Saint John's Bar. The insurance rates on vessels and cargoes from Jacksonville are more than 1 per cent. higher than from Fernandina, Brunswick, and Savannah, and the insurance companies admit that this is due solely to the extra risk imposed by the bar. It is asserted that on account of this higher premium the Jacksonville shippers had to pay last year $253,735 more than those of Fernandina and Savannah. The shippers for that reason sometimes insure their own cargoes, and it is stated that the insurance companies rather prefer not to take these risks, regarding them as extra-hazardous. An underwriter at Jacksonville approximately estimates the losses on cargoes wrecked, disabled, or damaged during the years from 1865 to 1880, between Fernandina and Cape

Canaveral, at $3,000,000, and it is his opinion that about one-half of that amount might have been saved if there had been a deep ship-channel at the entrance into Saint John's River.

For the same reason the freight rates from Jacksonville are higher than from other more favored ports. A considerable lumber business is transacted at Jacksonville, 60,000,000 feet having been shipped during the last calendar year.

The freight is $1 per thousand higher than from either Fernandina or Brunswick. It is estimated that 100,000,000 feet will be shipped during the year 1881, and there is no doubt that the lumber trade would rapidly increase in magnitude if safe and deep navigation existed on Saint John's Bar.

An active and growing business is now done in early vegetables and fruits, especially oranges. This fruit is coming into demand even in foreign countries, and as its cultivation promises good and certain remuneration, large numbers of citizens from other parts of the country are seeking homes and investing in orange groves on the Saint John's River and the adjacent country tributary to it.

There can be no doubt that cotton which is now taken to more distant ports would come to Jacksonville for export if vessels of deep draught could cross the bar and proceed to the city wharves.

Jacksonville is connected with Cedar Keys, on the Gulf of Mexico, by the Atlantic, Gulf and West India Transit Railroad. Another line, the Jacksonville, Pensacola and Mobile Railroad, runs in a westerly direction and will eventually connect Jacksonville with New Orleans, but at present it extends only as far as Chattahoochee, Gadsden County, Florida, a distance of 209 miles, with a branch from Tallahassee to the port of Saint Mark's, on the Gulf, and another from Live Oak to Dupont, Ga., connecting with the Savannah, Florida, and Western Railroad. It is expected that early next year the main line will have been completed to Pensacola and Mobile. Jacksonville will then be in direct communication by rail with New Orleans and the Mississippi Valley.

According to the census of 1880 the population of Florida is now 267,351, a gain of fully 42 per cent. since 1870. Present appearances indicate that the increase will continue. It is probable that the valley of the Saint John's River, embracing an area of about 8,000 square miles, will especially grow in population and in acreage of cultivated land, since the river affords ready means of sending the surplus products to market, and for receiving various commodities in return.

This improvement is located in the collection district of Saint John's; Jacksonville is the nearest port of entry.

Import duties collected in 1880, $98.91.

Since the adoption of the present project of improvement the following appropriations have been made:

By act approved June 14, 1880	$125,000
By act approved March 3, 1881	100,000
Total	225,000

The estimated cost of the improvement is $1,306,409.

There has been expended up to June 30, 1881, including outstanding liabilities, the sum of $42,296.92.

There had been no expenditures under this project previous to the beginning of the fiscal year.

The following drawings and papers accompany this report:

Chart of entrance, showing progress of work and recent changes of the bar.
Report of Lieut. W. L. Fisk, Corps of Engineers.
Table of commercial statistics.

Money statement.

July 1, 1880, amount available	$125,000 00	
Amount appropriated by act approved March 3, 1881	100,000 00	
		$225,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	28,521 42	
July 1, 1881, outstanding liabilities	13,775 50	
		42,296 92
July 1, 1881, amount available		182,703 08
Amount (estimated) required for completion of existing project		1,201,409 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		500,000 00

Abstract of proposals for constructing jetties at the mouth of Saint John's River, Florida, opened August 31, 1880.

No.	Names of bidders.	Per linear foot of mattress 54 feet wide overlaid with riprap stone 1 foot thick.			For riprap stone of 2,800 pounds to the cubic yard.
		First design.	Second design.	Third design.	
					Per cu. yd.
1	Frederick H. Cobb, Washington, D. C. *	$19 45 18 55	$19 45	$19 45 18 55	$4 85 3 85
2	Aaron S. Lara, Staunton, Va.; Rod'k G. Ross, Wilmington, N. C.; and F. P. Murphy, Washington, D. C.	12 34	12 49	11 59	3 34
3	John Brady, Brooklyn, N. Y	14 35	14 35	14 35	3 50
4	John F. Gaynor, Fayetteville, N. Y	16 40	16 40	16 40	4 50
5	Jos. H. Durkee, Jacksonville, Fla	27 00	27 00	27 00	4 00

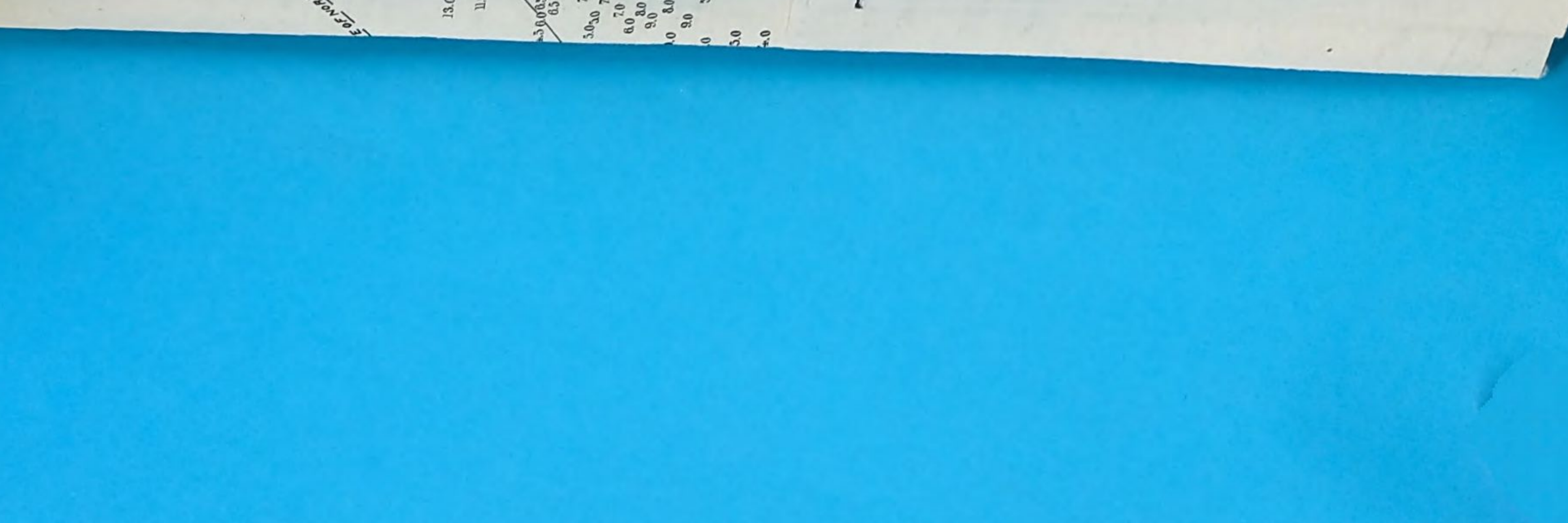
* Highest price for gneiss or granite; lowest for calcareous stone. Bid and bidder's bond informal.

Abstract of contract for constructing jetties at the mouth of Saint John's River, Florida.

Contractors.	Residence.	Date of contract.	Nature of work.	To be completed.
Lara, Ross & Co	Staunton, Va	September 4, 1880.	Constructing jetties at mouth of Saint John's River, Florida, under second design, and furnishing riprap stone at the prices stated.	June 30, 1881

Abstract of proposals for continuing construction of jetties at the mouth of Saint John's River, Florida, opened May 10, 1881.

No.	Names of bidders.	Mattresses.	Riprap stone, 2,700 pounds to the cubic yard.	Remarks.
		Per sq. yd.	*Per cub. yd.*	
1	John Brady, Brooklyn, N. Y	$0 68	$3 50	Proposal rejected by authority of the Chief of Engineers.
2	Jos. H. Durkee, Jacksonville, Fla	60	4 00	Contract awarded.
3	A. S. Lara, Staunton, Va., and John Kirby, New York City.	97	3 74	



IMPROVEMENT
OF
ST. JOHN'S RIVER, FLA.

showing the sites of the North and South Jetties, the progress made in the construction of the South Jetty to June 30th 1881, and recent changes on the bar.

Accompanying annual report dated July 15th 1881.

D. P. Gillmore
Lt. Col. Engrs. Bvt. Maj. Gen. U.S.A.

Scale
500' 0 1000' 2000' 3000'

PROPOSED SITE OF NORTH JETTY

January 1879

June 1881

Sailing line 1879

NORTH CHANNEL JUNE 1881

January 1879

June 1881

Pelican Bank

Sailing line of 1878

FORT GEORGE

Low Water Line of June 1881 / January 1879

High Water Line of June 1881 / January 1879

To New Light House at Mayport 5775 feet

Note: Soundings shown between brackets are taken in May 1881.

Abstract of contract for continuing construction of jetties at mouth of Saint John's River, Florida.

Contractor.	Residence.	Date of contract.	Nature of work.	To be completed.
Joseph H. Durkee.....	Jacksonville, Fla.	June 10, 1881	Constructing jetties at mouth of Saint John s River, Florida.	June 30, 1882

REPORT OF LIEUTENANT W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., July 1, 1881.

SIR: I have the honor to submit the following report of the progress of the work for the improvement of the bar at the mouth of Saint John's River, Florida, during the year 1880–'81:

The contractors reached Pilot Town with their tug, two large stone lighters and other plant on October 29, 1880. Since that time they have added three smaller lighters to their fleet, and another small one with a capstan will soon be built to replace the two yawl boats now used to hold the mats to the guide mast as they sink.

All work done has been on the south jetty.

A great deal of rain during October and November flooded the woods, making it very difficult to get logs, so that the first mat was not sunk until December 14. It was floated as far in shore as possible at high-tide and on range 1. From this mat to high-water mark the jetty was built by floating rafts of logs at high-tide as near as possible to where needed, and after the tide had fallen the mats were built in place, brushed and loaded with the requisite amount of stone. The lighters were floated, also at high-tide, as far in as was safe and the stone thrown overboard; at low-tide it was wheeled on barrows to the mats.

The shore end of the jetty is sunk so that the top of the stone is at the level of high-water mark. This portion of the jetty was not finished until March 11.

On range 1, between high and low water marks, 873.67 feet of apron were laid, and on range 2, 1,912.11 feet have been laid to and including June 30, or a total length of 2,785.78 feet.

The mats, varying in width from 20 to 87 feet, are 40 feet long, and are of the same construction as those used in Charleston Harbor, which are described on page 737, Appendix I of the Report of the Chief of Engineers for 1879.

Each mat has two strong wooden guide masts, one at each end, and both on the center line of the mat, so that when it is properly set both are on the established range; each mast is fastened to the outside log of the mat at the bottom and held upright by three braces; strong rope beckets are attached at the corners of the mats for towing, &c.

When water sufficiently deep to float the tug, lighters, &c., was reached, the following plan of setting the mats was adopted: The mat and 2 lighters of stone having been towed to the site of the work, usually a little before low-water slack, in order to avoid the strength of the tide, they are swung into the positions indicated in the accompanying sketch, and as each lighter is provided with a capstan, the combination can easily be placed exactly where it is desired.

The mat is placed close to the outside mast of the one last sunk; enough stone is distributed over it to sink it; the bridle lines are then slacked away, allowing the mat to settle slowly to the bottom; the lines to the anchored yawl boats keeping the mat close to the guide mast on the preceding one, as it goes down.

If the mat gets off the range, or too far from the adjacent one, the bridle lines are made fast, the mat remaining suspended until brought back to its place by means of the capstans and proper anchor lines. The remainder of the stone is then distributed.

Considerable delay has been caused at various times by lack of stone, to a great extent due to heavy weather, vessels being occasionally obliged to lie outside the bar some time waiting for a day sufficiently smooth to cross safely.

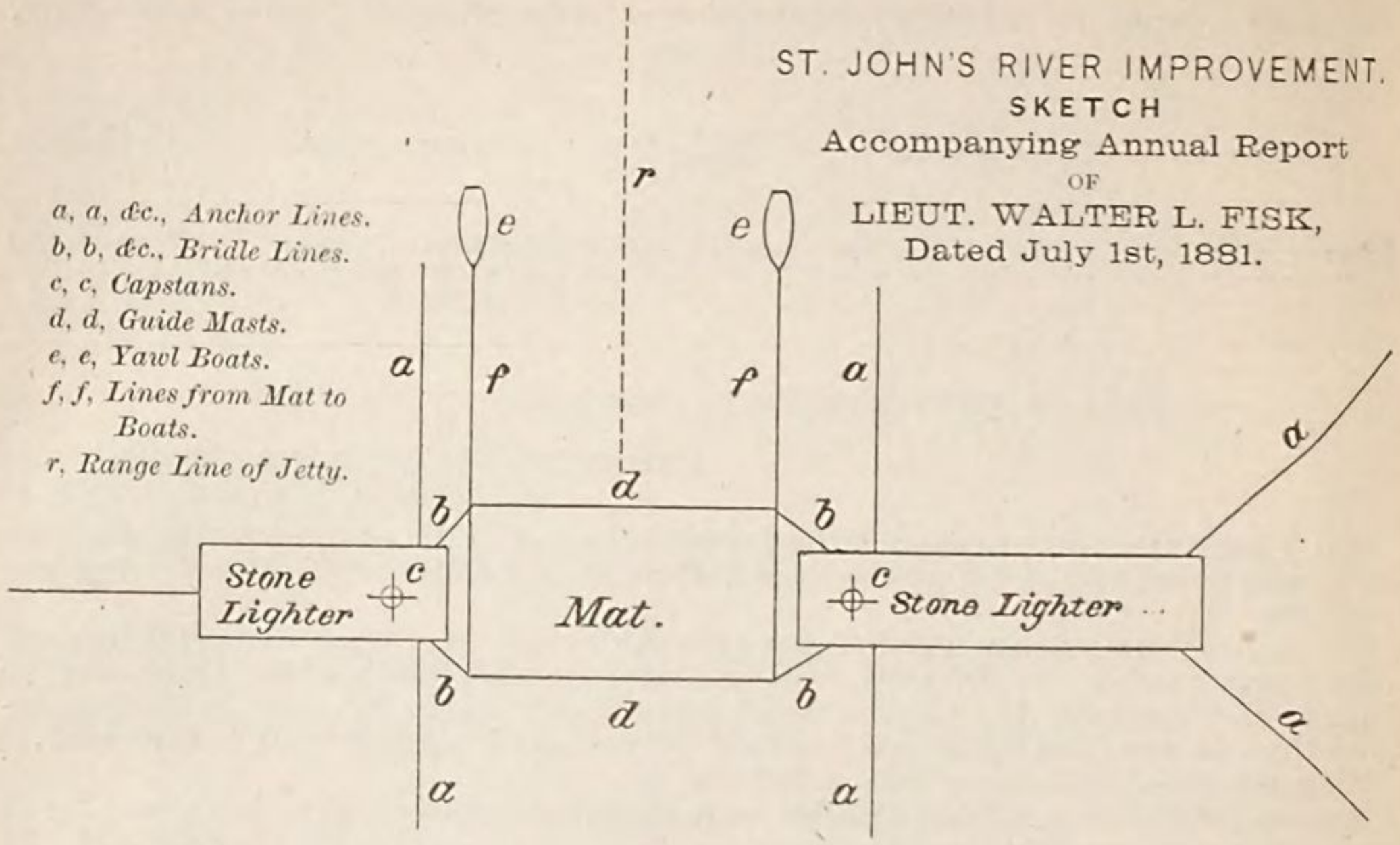
The only noticeable effect of the jetty so far is that it seems to have checked the advance of the shoal on the north side of the north channel, and to be gradually washing off the point of it.

The buoys of the north channel remain in the same positions they occupied on April 13, previously reported.

Very respectfully, your obedient servant,

W. L. FISK,
First Lieutenant of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, Bvt. Maj. Gen., U. S. A.



COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Jacksonville, Fla., from January 1, 1878, *to December* 31, 1880.

VESSELS ARRIVED.

Years.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1878.....	235	92, 267	2, 917	19	2, 979	118	10	653	56	264	95, 899	3, 091
1879.....	335	170, 872	5, 172	17	3, 008	108	23	12, 948	558	375	186, 829	5, 838
1880.....	353	161, 039	4, 487	21	4, 019	136	9	673	57	383	165, 731	4, 680

VESSELS CLEARED.

Years.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1878.....	245	94, 732	5, 838	34	6, 076	214	10	678	61	289	101, 486	6, 113
1879.....	335	169, 949	5, 077	34	5, 839	211	21	12, 908	559	390	188, 696	5, 847
1880.....	363	158, 733	4, 346	45	13, 526	428	10	716	72	418	172, 975	4, 846

Commercial statistics—Continued.

Years.	Value of exports.	Value of imports.	Duties collected.
1878	$74,035 47	$1,363 27	$181 52
1879	92,890 84	15,319 26	771 21
1880	94,680 00	888 40	98 91

EDWIN HIGGINS,
Deputy Collector.

J 14.

IMPROVEMENT OF VOLUSIA BAR, FLORIDA.

By act approved June 14, 1880, the sum of $5,000 was appropriated "for improving Volusia Bar, Florida."

The act also authorized the Secretary of War "to make such special contract for the prosecution of the work as may, in his judgment, best promote the interests of the government."

This was the first appropriation made for the work. A second appropriation of $5,500 was made by act approved March 3, 1881.

Volusia Bar is located at the south end of Lake George, about 162 miles from the mouth of the Saint John's River, at a point where the waters of the river discharge into the lake. A project for permanently improving this bar by means of two jetties, with a view of establishing a channel depth of 6 feet, was submitted with my report of July 16, 1879. Heretofore the low-river depth on the bar has occasionally not exceeded 4 to 4½ feet.

The cost of the project was estimated at $15,000.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

Proposals were invited August 3, 1880, for expending the first appropriation in creating and maintaining a channel 6 feet deep and 30 feet wide.

No formal specifications accompanied this call, but each bidder was expected to specify the method which he would follow, and if the method be new or peculiar, to give such a general description of it that the principles involved therein and their mode of application might be readily understood.

This unusual method of inviting proposals was followed in order that under the peculiar phraseology used in the act making the first appropriation the Secretary of War might adopt certain patented devices for deepening river channels if it should be deemed best to do so.

No response was made to this call.

The work was again advertised September 13, 1880. The specifications stated that intending bidders might adopt a method of their own, as under the previous call, but that if no bids advantageous to the United States were received the improvement would be made by means of one or two jetties.

The specifications contained a description of a jetty composed of a pole and brush mattress overlaid with riprap stone.

Only one formal proposal was made under the second call, viz, by

Messrs. Anderson & Blaisdell, of Boston, Mass., who proposed to follow the official plan. Owing to a misapprehension on their part, their bid was much too high. An informal bid was received from Mr. J. A. Cloud, of Jacksonville, Fla.

By authority of the Chief of Engineers these two parties were invited to offer new proposals until October 16, 1880.

Messrs. Anderson & Blaisdell alone responded to the call, offering to do the work at the rate of $2.95 per linear foot of jetty 12 feet wide. The contract was awarded to them on October 21, 1880.

It was decided to begin with the west jetty. Work was commenced December 18, 1880, and finished April 12, 1881, exhausting the first appropriation. One thousand nine hundred and fifty linear feet of jetty were laid, extending from the shore to about 3½ feet depth of water on the bar. For a length of 988 feet from shore the width of the mats is 6 feet, widening to 9 feet in a length of 32 feet, while the outer portion, 930 feet long, was made 12 feet wide.

All the mats are covered with stone averaging about 50 pounds per square foot of surface.

The height of the jetty along the crest varies from 2 to 2½ feet. Seven piles were driven as fenders to keep boats from running against the work.

OPERATIONS CONTEMPLATED FOR THE PRESENT FISCAL YEAR.

It is proposed to expend the sum of $5,500, appropriated by act approved March 3, 1881, in extending the west jetty across the bar to the 6-foot curve, and in beginning the east jetty. Some dredging on the bar may be necessary.

On May 28, 1881, proposals were invited for doing the jetty work, composed of a compact pole and brush mattress 12 inches thick, exclusive of the pole binders on top and bottom, covered with broken stone to a depth of from 6 to 18 inches, as may be directed.

Mr. D. V. Howell, of New York, was the only bidder. With the authority of the Chief of Engineers, his bid was rejected as being too high, and new proposals will be called for by circular letter.

If no advantageous offer is received the work will be done by special arrangement, in conformity to the requirements of the law on the subject.

Some statistics have been received having reference to the commerce and navigation that would be benefited by this improvement.

During last winter seven steamers made semi-weekly and tri-weekly trips over the bar, while three made weekly trips, ten steamers in all. These boats average about 140 feet in length, and draw from 4 to 5½ feet of water when laden.

It is stated that the greater part of five counties is mainly dependent upon this navigation for their supplies.

Two railroads are in operation from Saint John's River above Volusia Bar, which receive freight from the river boats. One line runs from Astoria, near Lake George, to Fort Mason on Lake Eustis, 27 miles in length; the other from Sanford to Orlando in Orange County, 23 miles in length.

The aggregate population, more or less dependent upon the river, in the vicinity of Volusia Bar, for all needed supplies, and as an outlet for their products, fruit, early vegetables, cotton, hides, &c., is estimated at from 35,000 to 40,000.

This work is located in the collection district of Saint John's. Jacksonville is the nearest port of entry.

Amount of duties collected in 1880, $9,891.

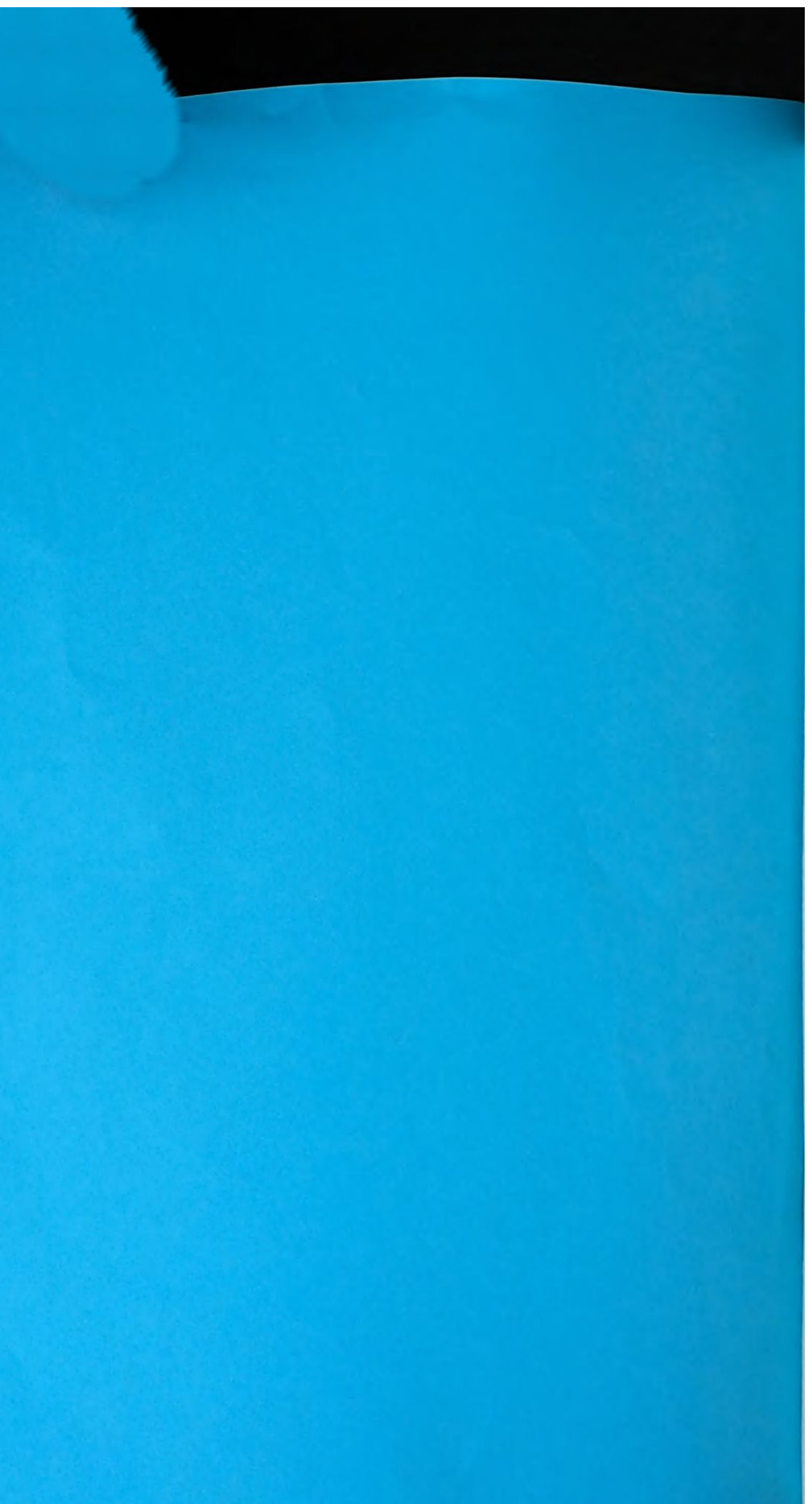


CHART
OF
VOLUSIABAR, FLORIDA

Showing location of work of improvement now in progress.

Accompanying annual report of July 15th 1881.

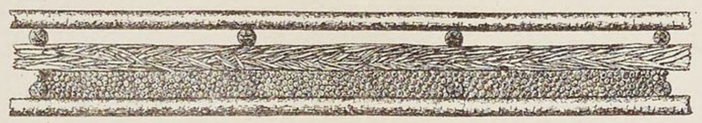
D. A. Gillmore
Lt. Col. Engrs. Bvt. Maj. Genl. U.S.A.

Scale.

100' 0 500' 1000'

The water level at the time of survey was 3ft below three spikes driven in the form of a triangle on the south east pile of beacon
A very low river there is a foot less water than is shown by the survey

Cross Section of Mattress at A.



Scale: 1:24

0 1 2 3 4 5 6 7 8 9 10'

PROPOSED SITE OF EAST JETTY

Palmetto or edge of shore

WEST JETTY

BEACON

A

PROPOSED EXTENSION

The following papers are transmitted herewith:

Chart of Volusia Bar, showing sites of jetties.
Report of First Lieut. W. L. Fisk, Corps of Engineers.

Money statement.

July 1, 1881, amount available	$5,000 00	
Amount appropriated by act approved March 3, 1881	5,500 00	
		$10,500 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	4,977 60	
July 1, 1881, outstanding liabilities	22 40	
	5,000 00	
July 1, 1881, amount available		5,500 00
Amount (estimated) required for completion of existing project		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		5,000 00

Abstract of proposal for improving Volusia Bar, Florida, opened October 16, 1880.

No.	Bidders.	By bidders own plan: for creating and maintaining a channel 6 feet deep and 30 feet wide, so nearly straight as to render navigation easy, safe, and convenient.	By official plan: for a mattress 12 feet wide, 1 foot thick, covered with 600 pounds of riprap stone per linear foot.
			Per lin. ft.
1	Anderson & Blaisdell, Boston, Mass		$2 95

Proposal accepted. Contract awarded at price stated. Work completed April, 1881.

REPORT OF LIEUTENANT W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Jacksonville, Fla., June 23, 1881.

SIR: I have the honor to submit the following report of work done at Volusia Bar, Florida, during the year ending June 30, 1881.

This work was under the supervision of Captain Post until the 1st of March, 1881, when I received it from him.

Work was begun on December 18, 1880, with the construction of mat No. 1, which was sunk the next day as the shore end of the west jetty. Up to the 1st of March, thirty-three mats, each 30 feet long, were built, of which thirty-two were 6 feet wide and one of 9 feet. Of these, thirty were sunk previous to that date, each with its complement of 50 pounds of stone per square foot of surface, completing a portion of the jetty 923 feet in length.

From March 1 until April 12, the date of completion of the contract, thirty mats, each 30 feet long by 12 feet wide, and one mat 17 feet by 12 feet, were built, and, with the three mats on hand on March 1, were sunk with stone as above. Spaces between the mats were filled with tussocks of marsh grass held in place by stakes and sand.

The total length of the jetty is 1,950 feet, and the free end is in 3.6 feet of water when the triangle referred to on the chart of Volusia Bar, survey of 1879, is 3.2 feet above the water.

This work is in the collection district of Saint John's, and Jacksonville is the nearest port of entry.

Very respectfully, your obedient servant,

W. L. FISK,
First Lieutenant of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, Bvt. Maj. Gen., U. S. A.

List of steamboats regularly crossing Volusia Bar.

Name.	Plying.		
	From—	To—	
Fred'k de Bary	Jacksonville	Sanford	One steamer of this line crosses daily each way.
George M. Bird	do	do	
Florence	do	do	
Rosa	do	do	
Arrow	do	do	Twice a week each way.
Volusia	do	do	
City of Sanford	do	do	Twice a week each way.
Wekiwa	do	Salt Lake	Weekly.

J 15.

EXAMINATION OF EDISTO RIVER, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, December 31, 1880.

GENERAL: I have the honor to submit the following report of an examination of the Edisto River, South Carolina, with an estimate of the cost of its improvement, provided for by section 2 of the act approved June 14, 1880.

This duty was assigned to me by letter dated June 17, 1880.

The examination was conducted by Capt. J. C. Post, United States Engineers, whose report is herewith transmitted. He was assisted by Mr. J. H. Hallonquist.

The examination was made during the months of September and October, 1880, when the river was in a favorable condition for the work, being only about 12 inches above extreme low-water.

The Edisto is one of the principal rivers of South Carolina. It is formed by the junction of the North and South Forks, which unite in the southern part of Orangeburg County. The South Fork, commonly known as the South Edisto, is the main river.

The Edisto rises in Edgefield County. It flows through the central portion of Aiken County, then forms the boundary between the counties of Barnwell and Orangeburg, and finally passes through Colleton County to the sea, near Saint Helena Sound.

The river changes its name several times. From its junction with the North Fork at Milltown, about 30 miles from the mouth, it is called simply the Edisto; thence for a few miles to the point where Dawhoo River, a narrow, tortuous tidal stream, connects it with the North Edisto, an arm of the sea, it is known as the Ponpon River, and its lower reach of about 20 miles is termed the South Edisto.

The Edisto receives a considerable number of tributaries, none of which are of any importance except the North Fork and the Four-Hole Swamp. The area of country drained by the river is estimated at 3,000 square miles, its total length being about 300 miles. The upper portion for about two-thirds of its entire length generally follows a southeasterly direction. For the last 100 miles it has a southerly course.

The examination commenced at Guignard's Landing, in Aiken County, about 77 miles above the junction of the Edisto with its North Fork, and extended to the mouth, a total length of 260 miles. Two railroads cross the river on this line, viz, the South Carolina Railroad, about ½ a mile below the junction, and the Charleston and Savannah Railroad at

Jacksonborough, 144 miles lower down, and about 40 miles from the mouth.

The upper river for the first 77 miles flows through bottom land averaging ¾ mile in width on each side of it. The banks are only about 1 foot above the low-water stage. Freshets rise to a height of about 5 feet, when the whole adjacent swamp becomes overflowed. To this large expansion is doubtless to be attributed the fact that the floods do not rise very high, and are seldom destructive. From the upper to the lower railroad crossing the banks of the river are bluffy.

The surface velocities were found to be quite uniformly about 3 miles per hour as low down as the head of the tidal compartment of the river, which was found to be about 75 miles from its mouth. The mean rise and fall of tide is 2½ feet at the crossing of the Charleston and Savannah Railroad, and about 6 feet at the mouth. The water is fresh to some distance below the junction with the Dawhoo River. No levels were taken during the examination. The railroad levels show a fall of water surface of about 100 feet from the upper to the lower railroad crossing, a distance of 144 miles.

The river course is for the greater part tortuous, though occasionally alternating with comparatively straight reaches or long sinuous sweeps. At several places the bends are so excessive that while their length is about one mile the distance across the neck is only a few feet.

These narrow strips are frequently cut through at freshets, and form rapids. Over 20 places were noted during the examination where such new channels or cut-offs are now in process of formation.

In the upper division, extending as far down as the junction with the North Fork, the flow of the stream is disturbed and weakened in many places by branches which leave the main channel at certain points and rejoin it lower down. At a number of places, both above and below the junction, the river is more or less obstructed by logs and snags, as well as by shoals, consisting generally of sand, but at some points of hard clay.

Pile obstructions were found at two places. Those just below Milltown, driven during the late civil war, seem to be especially dangerous.

The needed improvement in the navigation of the stream would, it is thought, be secured by the removal of the obstructions specified in Captain Post's report.

The quantity of valuable timber growing in the country bordering on the river and its tributaries is very great, but the trade is at present confined to the season of freshets.

While the examination was in progress the banks were strewn with wrecked rafts, and hundreds of rafts were seen tied to the banks waiting for a rise. An improvement of the river would undoubtedly result in a great development of the timber and lumber business. The same may be said of rice culture, to which extensive areas of land along the banks appear to be well adapted.

A few statistics relating to these matters are given in the accompanying report.

Considering the importance and great length of the Edisto River, and the character of the country through which it flows, the estimated cost of improving it, so as to establish a safe navigation at all seasons of the year for light-draft steamboats from the sea to the junction of the North and South Forks, and perhaps some distance higher up, and for rafts and flat-boats from the junction to Guinguard's Landing, seems to be moderate.

It is not deemed advisable to extend the improvement beyond the

point last named, as the obstructions are too numerous and the river's regimen too unstable to render such works permanent, unless built at great cost.

It is believed that rafting there must continue to be dependent upon freshets. The same remark applies to the North Fork.

The plan of improvement suggested by Captain Post is approved. It comprises:

1. Enlargement and clearing of all the new channels now in progress of formation.
2. Forming new channels across necks of bends where needed.
3. Shutting off lateral arms which now weaken the stream.
4. Removal of logs, snags, and pile obstructions.
5. Removal of shoals of sand and clay; in one case by building a deflecting jetty.

The total cost of these improvements, exclusive of contingent expenses, is estimated at $30,350.

By adding 10 per cent., to cover superintendence and inspections, the estimate is increased to $33,385.

No appropriation has ever been made by Congress for improving the Edisto River.

This improvement is located in the collection district of Charleston; Charleston, Beaufort, and Savannah, the nearest ports of entry.

The report of Capt. J. C. Post, Corps of Engineers, U. S. A., is sent herewith.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., December 22, 1880.

COLONEL: In compliance with the instructions contained in your letter of September 14, 1880, I have to submit the following report of the examination of Edisto River, South Carolina.

The Edisto River is formed by the junction of two branches called the North and South Forks, both of which rise in Edgefield County, South Carolina, and unite half a mile above the crossing of the South Carolina Railroad, in the southern portion of Orangeburg County. From this point it flows undivided to its junction with the Dawhoo River, a distance of 160 miles. For a few miles above this junction it is known as the Ponpon River, and below it is called the South Edisto. Dawhoo River is a narrow, tortuous stream, about 15 miles long, connecting the Edisto with an arm of the sea called the North Edisto. Dawhoo River, the upper portion of the South Edisto, and the upper portion of the North Edisto, known as the Wadmalaw River, form a part of the inland water route between Beaufort and Charleston.

The examination of the river was commenced on the South Fork, at Guinguard's Landing, about 77 miles above the junction, and extended to the coast, a distance of 260 miles. Above this landing it is narrow and obstructed to such a degree by logs and sand shoals that it was thought unnecessary to commence at a higher point. The water at the time was about 1 foot above extreme low-water, and the current was ascertained to be about 3 miles an hour, and generally uniform to Kennedy's Bridge, where a diminution of $\frac{1}{2}$ mile an hour was observed. From the lines of levels taken on the South Carolina and Charleston and Savannah Railroads the fall in the river from the crossing of the former to that of the latter is about 100 feet. The distance between these bridges by the river is 144 miles.

Above the junction the South Fork flows in a tortuous channel through bottom or swamp lands about 1½ miles wide. These bottoms are soft, and their general level is seldom more than 1 foot above the surface of the water at its average stage. They are completely overflowed during freshets, which in the upper portion of this river rise about 5 feet. The increased current at such times and the obstruction of different portions of the river channel by logs and floating débris frequently result in new channels. These usually connect the extremities of bends, and, having a greater fall through them than around the bends, generally remain the channel after the freshet subsides and sometimes form rapids.

From the junction to the coast the river flows in a winding course. To the crossing of the Charleston and Savannah Railway, at Jacksonborough, it lies between banks varying from 3 to 30 feet in height; generally those below 8 feet in height are of sand and those greater of clay. Below this crossing the rice lands begin and the banks are low. This cultivation extends as far as fresh water can be obtained, which is below the junction with the Dawhoo. The river is obstructed with logs and many shoals as far down as Jacksonborough. No other obstructions exist to the sea in either the South Edisto, Dawhoo, and the North Edisto, except in the Edisto near Milltown, where there is a shoal and pile obstructions.

DETAILED DESCRIPTION OF THE RIVER.

Guinguard's to Holman's Bridge—30½ miles. The river is about 55 feet wide and 3½ feet deep for about 17 miles. Beyond it increases, though somewhat irregularly, to 125 feet wide and 4 feet deep at the bridge. There are some 19 places where streams varying from 8 to 15 feet wide leave the river, producing shoals, and enter it again below. There are also two new channels, one 6½ miles and the other 5 miles above Holman's, which are forming across bends. These will reduce the distance about 350 feet. New Bridge is 17½ miles above Holman's.

Holman's to Binnaker's Bridge—11 miles. The river is generally wide and straight. There are 13 streams, varying from 6 to 15 feet wide, which leave the river and join it again, and there are also four new channels across bends partially open, which save some 3,550 feet. The first of the latter is about 550 yards, the second 3½ miles, the third 5 miles, and the fourth 8 miles below Holman's.

Binnaker's to New Bridge No. 2—11 miles. Average width of river, 125 feet; depth, 5 feet. Four streams, from 6 to 10 feet in width, leave the river and return to it. Seven new channels across bends are partially open, which reduce the length about 3,000 feet. The first is 1 mile, the second immediately below the first, the third 2 miles, the fourth 2¾ miles, the fifth 5½ miles, the sixth 6¾ miles, and the seventh 8¾ miles below Binnaker's.

New Bridge No. 2 *to South Carolina Railroad Bridge*—24¾ miles. In this section the river has shoal places in bends. Two streams, about 6 feet wide, leave the river and return to it again within a short distance. Four new channels have been partially formed across bends. Distance around bends, 3,180 feet; length of new channels, 120 feet. The fourth of these requires special attention, as it avoids a dangerous curve. Width of river, 150 feet; depth, 5 feet.

South Carolina Railroad Bridge to Ferry—20 miles. About 100 feet below the bridge a row of piles, probably the remains of an old bridge, obstructs the channel. A short distance below this a number of trees partly in the water, together with snags, are gradually forming new shoals. These are to be found at intervals to River's Bridge, a distance of 9 miles. There are also two rapids, 50 feet long, in each of which the fall was estimated to be about 1 foot. These are formed by new channels across bends where there is considerable fall, becoming obstructed by logs, &c. The greater portion of the water now flows through these new channels, and those around the bends are shoaling. Width of river, 200 feet; depth, 4 feet.

Ferry to Kennedy's Bridge—34 miles. In the first 19 miles there are two shoals of hard clay obstructing the channels. In the remaining 15 miles there are several horseshoe bends of over a mile in length, with only a few feet between their extremities. There are also shoals at several of the bends, and 2 rapids, each 100 feet long, across other bends, formed as already stated, in which the fall was estimated to be 3 feet. The width and depth remain the same.

Kennedy's to Good Hope Landing—51 miles. There is a rapid in the first 12 miles about 300 yards long. It would improve the navigation of the river to close this and clear the old channel of logs, &c. In the remaining 39 miles nothing but imbedded logs obstruct the channel. The width and depth of the river continue the same.

Good Hope to Jacksonborough—39 miles. At Good Hope the influence of the rise and fall of the tide is felt to the extent of 2 or 3 inches. About 12 miles below a shoal of indurated clay about ½ mile long narrows the channel by projecting into it 6 feet. It is from 2 to 3 feet in thickness, and can be removed at low-water. Width of river, 300 feet; depth at low-water, 8 feet. Tide rises and falls 2½ feet at Jacksonborough.

Jacksonborough to mouth of river—39 miles. A few hundred feet above Willtown, or Mill-

town, 9 miles below Jacksonborough, an extensive sand shoal has formed within the past year to such an extent that the channel has become reduced to 60 feet in width, with a depth of 9 feet at low-water. The river here makes a bend of about 100 degrees. Width at Willtown, 950 feet; rise and fall of the tide, 6 feet. About 1,000 yards below a double row of piles, driven during the late war, obstructs the channel. They are 289 in number, of which 120 are in the channel proper. These latter have been cut off by raftsmen about 3 to 4 feet below extreme low-water, and form a very dangerous obstruction to navigation. Dawhoo River enters about 5 miles below these. This river and the North and South Edisto are free from obstructions and of sufficient size to accommodate the present inland commerce.

PROPOSED IMPROVEMENTS.

It is proposed to clear the channel of the piles below Willtown and at the South Carolina Bridge and remove the logs, snags, and shoals, clay and sand, obstructing the river. In doing this it is proposed to enlarge and clear all the new channels save one, that between Kennedy's and Good Hope Landing, and make several others across the bends contained in the section between the ferry and Kennedy's Bridge. It is expected that the old channels will fill up as soon as the new ones are fully opened. The rivers should also be confined to a single channel above the junction by closing all the small streams diverting the water. All of this can be done with a reasonable prospect of success at a comparatively small cost, with the exception of the removal of the sand shoal above Willtown. This shoal has apparently a sufficient channel across it for all the possible wants of commerce, even when the improvements are made. This would be true were it not for the very sharp bend and swift current at this point, which together render it exceedingly difficult for vessels of any kind or rafts to keep the channel. A deflecting jetty 100 feet long will be required to remove the shoal and keep it from reforming, and even this may not be sufficient.

The following is the estimate of the cost of these improvements, viz:

Clearing river and concentrating currents from Guinguard's to Holman's Bridge	$4,800
Same from Holman's to Binnaker's Bridge	1,500
Same from Binnaker's to New Bridge No. 2	3,900
Same from New Bridge to South Carolina Railroad Bridge	3,600
Clearing river from South Carolina Railroad to Ferry	3,800
Clearing river from Ferry to Kennedy's Bridge	6,900
Clearing river from Kennedy's to Good Hope Landing	1,150
Clearing river from Good Hope to Jacksonborough	2,100
Constructing jetty, $2,000; removing piles near Willtown $600	2,600
Total	30,350

These estimates are based upon removing the obstructions by hand during the low stages of the river.

PRODUCTIONS OF THE SURROUNDING COUNTRY, AND PROBABLE COMMERCE OF THE RIVER, IF IMPROVED.

The principal productions of the country are timber, lumber, and rice. Above the junction there is an immense amount of valuable timber, such as yellow pine, hickory, gum, and white and red oak, in the immediate vicinity of the river. Large quantities are already sent to market, but the trade, on account of the obstructions, is now restricted to the seasons of high-water. The production of lumber for this same reason is limited to the requirements of home consumption. Rice culture has only recently been commenced in this section, and there is a very considerable amount of land suitable for it. All the rice grown has, at the present time, to be transported 18 miles by land to the South Carolina Railroad, and this is an expense too great to permit a rapid development of this interest.

Below the junction there are 5 large saw-mills whose shipments now amount to 800,000 feet a month, besides several other smaller mills.

With the proposed improvements all of these enterprises would be extended to a very large degree, and light-draught steamers could easily reach the junction, and probably much higher. The rice planted below Jacksonborough would also be benefited greatly.

The North Fork of the river was not examined, as from the best information that could be obtained it was ascertained to be of so little depth that it was not even navigable for rafts, except in the highest stages of the water. At the junction with the South Fork it is 50 feet wide and about 5 feet deep.

A chart of the river compiled from Mill's Atlas and the survey, accompanies this report.

The field work of the survey was by your direction intrusted to Mr. J. H. Hallonquist, who deserves commendation for the careful and intelligent manner in which he collected the data pertaining to the river.

This improvement is located in the collection district of Charleston. Charleston, Beaufort, and Savannah are the nearest ports of entry.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 16.

EXAMINATION OF SALKIEHATCHIE RIVER, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, December 29, 1880.

GENERAL: I have the honor to submit the following report of an examination of the Salkiehatchie River, South Carolina, with an estimate of the cost of improvement, provided for by section 2 of the act approved June 14, 1880, and assigned to my charge by letter dated June 17, 1880:

The examination was conducted by Capt. J. C. Post, United States Corps of Engineers, whose report is herewith transmitted. He was assisted by Mr. J. H. Hallonquist.

There are two rivers named Salkiehatchie in South Carolina, viz, the Big Salkiehatchie and the Little Salkiehatchie, which unite at a point about 80 miles distant by river from the sea-coast. Below the crossing of the Charleston and Savannah Railroad, which is about 24 miles below the junction of the two rivers, the stream is called the Combahee; but it is not known precisely at what point this change of name takes place The Combahee discharges into Saint Helena Sound about midway between the cities of Charleston and Savannah.

The mean rise and fall of tides in Saint Helena Sound is 5.9 feet; at the railway crossing, or nearly 60 miles from the river's mouth, it is 2.5 feet, and the tidal influence is felt about 20 miles above that point.

The Little Salkiehatchie was not examined. It was found to be much obstructed by logs and bars even within a few miles from its mouth, and higher up it is known to be still more so.

The Big Salkiehatchie rises in Aiken County, South Carolina, about 20 miles from the boundary line between South Carolina and Georgia, and flows through Barnwell County. Lower down it forms the boundary between Beaufort and Hampton Counties on the west and Colleton County on the east bank. The general course of the river is about south 40 degrees east.

The examination was commenced at the point where Toby's Creek enters the river, about 4 miles from Barnwell, and extended down to Hickory Hill, 12 miles below the Charleston and Savannah Railroad bridge, a total distance of about 156 miles. The examination was not carried further, as it was ascertained that from Hickory Hill to the sea the river was free and open for all purposes of traffic needed.

The course of the river is generally very tortuous. It flows through a low bottom land; its banks are about on the same level with the surface of the water at low stage, and are therefore overflowed during freshets, which, however, rarely rise higher than about 2½ feet. Between the point where the Little Salkiehatchie joins the river and the Charles-

ton and Savannah Railroad bridge the banks rise to the exceptional height of 4 or 5 feet.

The river flows through a soft alluvial stratum from 6 inches to 2 feet thick, resting on a substratum of sand. The country which it drains is well timbered, yellow pine predominating, while hickory, white and red oak, ash, and cypress abound. Below the railroad crossing, the lands bordering on the river are devoted to rice culture.

The regimen of the river is extremely irregular. For a length of nearly 110 miles from Toby's Creek down it is unfit during low stages for continuous navigation, even by rafts and the lightest kind of flat-boats. At several places it practically ceases to be a stream, and becomes divided into numerous insignificant streamlets. This is notably the case in the reaches known as Weekly Sand Bar, 36 miles from Toby's Creek; Murdock's Sand Drags, 88 miles, and Weekly Sand Drags, 105 miles from Toby's Creek. These obstructions and the principal features of the river generally are briefly described in a table inserted below. The first 20 miles of the river below Toby's Creek are so much obstructed by logs and sand-bars that it was impossible to pass over this reach in a light canoe. At Hickory Hill there are two rows of piles, driven during the late civil war, which prevent boats from ascending to the junction of the two Salkiehatchies.

The river receives a number of small tributaries, the more important of which, Whippy Swamp, enters it from the west near Toby's Bluff, 84 miles below Toby's Creek.

Where the Salkiehatchie runs in one channel only, it shows a gradually increasing size. At a distance of 20 miles below Toby's Creek its width, at low-water, is only 25 feet, its depth 1 foot; about 50 miles below the same point the width is 60 feet and the depth 6 feet, while 50 miles lower down the same depth is found with a width of 90 feet. Just below the junction with the Little Salkiehatchie the width is 120 feet and the depth 5 feet; and the lowest reach of 12 miles examined showed widths of from 200 to 400 feet, and depths of from 8 to 12 feet.

At the time when the examination was made the river was at a low stage, and the currents were generally moderate and quite uniform, the velocity being about 2 miles per hour, except where affected by the tide in the lower reaches.

The improvement recommended by Captain Post comprises the removal of the pile obstructions at Hickory Hill; and the removal of logs and the shoals accumulated around them, on that portion of the stream between the railroad bridge and a point 5 miles above Toby's Bluff, a length of about 65 miles. Through the Weekly and Murdock sand-drags, cuttings would have to be made to create a channel of sufficient dimensions to permit the passage of rafts and flat-boats. The cost of these improvements, which it is thought would be comparatively permanent, not including contingent expenses, is estimated by Captain Post at $16,400.

A fair allowance for salaries of an assistant engineer and inspector would probably carry the estimate to $18,000.

It is not considered advisable to improve the river above the point indicated by Captain Post, as the expense would be very great in proportion to the benefit to be secured.

The improvement would undoubtedly aid the timber and lumber trade of the country adjacent to the river, and would perhaps develop some local movement in naval stores.

A few statistics are given in Captain Post's report.

Memoranda relating to obstructions and characteristic features of the Salkiehatchie River, South Carolina, below Toby's Creek.

Name of place.	Distance below starting point.	Length of reach.	Remarks.
	Miles.	*Miles.*	
Toby's Creek..	.....	.....	Starting point of examination.
		20	Greatly obstructed by logs and sand-bars. Hercules Creek enters on left bank.
George Creek..	20		
		5	River 25 feet wide, 1 foot deep. Many logs and sand-bars.
		1½	River divided into numerous streamlets. Bird Creek enters on left bank.
		3	River runs in one channel 50 feet wide; mean depth, 4 feet.
Beauford's B'ge	29½		
		4	River runs in one channel 50 feet wide; mean depth, 4 feet.
		2	River divides from time to time into streamlets 2 to 5 feet wide, 6 inches to 2 feet deep. Will Branch enters on right bank at end of reach.
		3	*Weekly Sand Bars;* river still more divided—79 different streamlets.
		9	River forms twelve channels, averaging 15 feet width, 4 feet depth.
River's Bridge.	47½	.....	River runs here in two channels; the largest is 60 feet wide, 6 feet deep.
		1	River forms but one channel.
		5	River is 60 feet wide, with good depth.
		6½	River again divides into many channels, the largest 10 feet wide and shallow. Priest's Branch enters on left bank.
		1	River forms again one channel 60 feet wide and 6 feet deep.
Braxton's Ford	61		
		2	River forms again one channel 60 feet wide and 6 feet deep.
		10	River divides alternately into numerous streamlets and a good-sized stream.
		11	River runs in one channel as a good sized-stream.
Toby's Bluff ...	84	.....	Just below the bluff Whippy Swamp enters the river on right bank.
		3	River runs in one channel of increased size.
		¾	*Murdock's Sand Drags;* river runs in numerous insignificant channels.
		9¼	River forms one channel 90 feet wide 6 feet deep.
Niles's Bridge .	97		
		4	River forms one channel 90 feet wide 6 feet deep.
		4	River narrows down to 20 feet width and 6 feet depth.
		½	*Weekly Sand Drags;* river reduced to 12 feet width and less than 1 foot depth.
		¼	River forms a rapid in cut across bend; just below joined by five creeks.
		10¾	River gradually widens and deepens until it is 60 feet wide and 6 feet deep.
Junction with Little Salkiehatchie.	119½	.....	River 120 feet wide, 5 feet deep. Little Salkiehatchie 45 feet wide at its mouth.
		24	River is fairly wide and straight; in some places shoal and obstructed by logs. Banks bluffy. The following creeks enter it on the left bank: Sand's Run, Bull Brook, Black Creek, Boggy Cut Creek, Horse Tavern Creek.
Charleston and Savannah Railroad Bridge.	143½	.....	River 150 feet wide; mean rise and fall of tide, 2.5 feet.
		12	River very tortuous but free from obstructions. Width varies from 200 to 400 feet; depth from 8 to 12 feet. The banks are low.
Hickory Hill...	155½	.....	River obstructed by piles. Lower down, to the mouth, the river (Combahee) is entirely free. Terminal point of examination.

No appropriation has ever been made by the general government for improving the Salkiehatchie. It appears that many years ago the State government of South Carolina expended $30,000 in improving the river as high up as Toby's Creek. The narrow channel existing through the Weekly Sand Drags is believed to be a remnant of that improvement.

This work is located in the collection district of Charleston, S. C. Beaufort is the nearest port of entry.

The following papers are sent with this report:

1. Report of Capt. J. C. Post, Corps of Engineers, United States Army.
2. Sketch map of the Salkiehatchie River.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., December 9, 1880.

COLONEL: In compliance with the instructions contained in your letter of September 14, 1880, I have to submit the following report of the examination of the Salkiehatchie River, South Carolina.

The Salkiehatchie River is formed by the junction of two rivers, the Big and Little Salkiehatchie, which unite about 82 miles from the coast. Its lower portion, that below the crossing of the Charleston and Savannah Railway, is generally called the Combahee, but it is not definitely known at what point the change in name takes place.

The examination was commenced at Toby's Creek on the Big Salkiehatchie and extended 156 miles to Hickory Hill Landing, a point about 12½ miles below the railroad bridge and 46 miles by the river from the coast. From Toby's Creek to within ½ a mile of the junction of the two rivers, a distance of about 119 miles, the river flows in a tortuous course through bottom lands 1½ miles to 2 miles wide. These consist of a stratum of soft alluvial matter and decayed vegetation, from 6 inches to 2 feet in thickness, overlying a bed of sand which constitutes the bottom of the river. The banks are low, nearly on a level with the water at the low stage, and are overflowed every freshet. During these, which seldom exceed a rise more than 2½ feet, the increased current opens new channels through the unstable alluvial covering of the sand, and this continued from time to time has resulted in what are called sand drags or bars which completely obstruct the river at several points. Below the junction the river banks are generally bluffs of some considerable height, until the crossing of the railroad is reached. Here their character again changes and the land is low on both sides and planted very generally in rice. These plantations extend as far down as fresh water can be obtained, which is nearly to the mouth of the river.

DETAILED DESCRIPTION.

Toby's Creek to George's Creek—20 miles. This portion of the river was so obstructed that it was impossible to pass over it in a canoe. The country abounds in an excellent quality of yellow-pine timber, of almost unlimited quantity and remarkably easy of access. It would not be practicable, however, to improve this section of the river sufficiently to float the rafts through without a very great expense and an additional yearly expenditure to keep up the improvements.

George's Creek to Beauford's Bridge—9½ miles. For a distance of 5 miles from George's Creek the river is 25 feet wide and 1 foot deep. Beyond this it divides into a number of streams, which unite about 3 miles above Beauford's Bridge. From this point to the bridge it is 50 feet wide, with an average depth of 4 feet.

Beauford's Bridge to River's Bridge—18 miles. The same width and depth continues for 4 miles, being kept open at all times for fishing purposes In the next 2 miles the river divides from time to time into side channels, until there are some 79 of these, varying from 2 to 5 feet in width and from 6 inches to 3 feet in depth, through which all the water passes. This division is maintained for about three miles, and is called Weekly Sand Bars, after which the streams unite and form about a dozen channels, with an average width of 15 feet and a depth of 4 feet.

River's Bridge to Braxton's Ford—13½ miles. At this point the streams again unite into two channels, the largest of which is 60 feet wide and 6 feet deep. One mile below the bridge these two become one, and from thence for about 5 miles it continues about 60 feet wide, with a good depth. It then divides again, and the main channel is reduced to a width of 10 feet, with but little depth. This continues to within a mile of the ford, where it is rejoined by some of its scattered waters, and the river resumes its former size.

Braxton's Ford to Niles's Bridge—36 miles. Below the ford the river retains the same dimensions for about 2 miles, after which it is again divided and is alternately a good-sized stream and a number of streamlets for about 10 miles. Beyond this it is a good-sized stream again for 11 miles to Toby's Bluff, just below which Whippy Swamp, a stream of almost the same size as the Salkiehatchie, empties into it. From this junction to a place called Murdock's Sand Drags, a distance of 3 miles, the river has an increased width and depth. These sand drags are formed in a similar manner to the Weekly Sand Bars, and extend for ¾ of a mile. Below these the river increases in size to Niles's Bridge, where it is 90 feet wide and 6 feet deep.

Niles's Bridge to Junction—22½ miles. For 4 miles the river continues about the same, after which it again narrows to 20 feet in width, remaining the same in depth, for about 4 miles to the Weekly Sand Drags, where it is about 12 feet wide and less than a foot in depth. These continue about ½ a mile, the channel remaining the same. Below the river remains still narrow, but increases in depth, with the exception of a few shoals, for a distance of 3 miles. At this point there is a rapid nearly ¼ of a mile in length.

This is formed by the river becoming filled with floating logs and *débris*, which lodge in a bend and obstruct the channel. The water then makes a new channel, connecting the extremities of the bend, and there is the same fall in this shorter channel as there was in the larger one around the bend, hence greater velocity. The rapid is also considerably obstructed by roots, logs, &c. Below this the river is joined by five small streams, and becomes 40 feet wide. Thence it widens till just above its junction with the Little Salkiehatchie, a distance of 3 miles, it becomes 60 feet wide and 6 feet deep, while at the junction it increases its width to 120 feet and is 5 feet deep. The Little Salkiehatchie is about about 45 feet wide at its mouth.

Junction to Hickory Hill—36½ miles. The river continues wide and fairly straight, though in some places shoal and obstructed with logs, to the railroad bridge, a distance of 24 miles. From this point to Hickory Hill Landing it is free from all obstructions, and averages from 200 to 400 feet in width, and from 8 to 12 feet in depth. It is exceedingly tortuous, with low banks.

At Hickory Hill 2 rows of piles, driven during the late war, still obstruct navigation. Part of these are visible at low-water, and others have been broken or cut off by the raftsmen, and are always covered. They form a serious obstacle, and prevent boats or vessels from passing beyond this landing. With their removal and a comparatively small expenditure, light-draught boats could reach the junction of the two rivers.

Below Hickory Hill the river was not examined, as it was ascertained that the channel was free, and all that was needed for the commerce of that section.

The current of the river is about 2 miles an hour down to where the tidal influence is felt. The mean rise and fall, due to the backing up of the tide, is about 2½ feet at the railroad bridge. This action extends to within a few miles of the junction.

PRODUCTIONS OF THE SURROUNDING COUNTRY, AND PROBABLE COMMERCE OF THE RIVER, IF IMPROVED.

The principal production of the upper portion of this river is timber, and, below the railroad crossing, rice. The marketable woods are pine, hickory, red and white oak, ash, cypress, and poplar. Above the junction the shipments now amount to 500,000 feet of timber, 200,000 feet of lumber, and 500,000 shingles yearly. This, it is estimated, would be increased to 10,000,000 or 15,000,000 feet of lumber and timber, if the river should be improved so as to allow the passage of rafts and flats to a few miles above Toby's Bluff. The production of naval stores would also probably be undertaken on a large scale.

Below the junction, as well as on the Little Salkiehatchie, large quantities of ranging timber, as well as lumber and shingles, are shipped yearly.

PROPOSED IMPROVEMENT.

The improvements proposed consist of removing the pile obstruction at Hickory Hill and clearing the river of logs and the sand shoals accumulated around them, from a point 5 miles above Toby's Bluff to the railroad bridge. This includes clearing the rapids mentioned as being midway between the junction and Niles's Bridge. Through the Weekly and Murdock's Sand Drags it is proposed to concentrate a sufficient amount of water into a single channel to accommodate rafts and flat-boats. This, it is thought, can be done at a slight cost and with a reasonable prospect of permanency.

The following is the estimate of the cost of these improvements, viz:

Clearing the river and concentrating the current from 5 miles above Toby's Bluff to junction	$11,000
Clearing the river from junction to railroad bridge	5,000
Removing pile obstructions at Hickory Hill	400
Total	16,400

The estimates are based upon removing the obstructions by hand during the low stages of the river. These generally occur during the summer.

The Little Salkiehatchie was not examined. From the best information that could be obtained it was learned that this river contained sufficient water for light-draught navigation for only a few miles, and even in this portion it is much obstructed by logs and bars. Some of the raftsmen prefer it, however, to the Big Salkiehatchie on account of its freedom from sand drags.

I am informed that about thirty years ago the State of South Carolina appropriated some $30,000 for the improvement of this river. The channel through the Weekly Sand Drag is apparently all that remains of this improvement.

The field work of this survey was, by your direction, intrusted to Mr. J. H. Hallonquist.

This improvement is located in the collection district of Charleston. This river is its southern boundary. Charleston and Beaufort are the nearest ports of entry.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 17.

SURVEY FOR THE REOPENING OF THE SANTEE CANAL, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, January 26, 1881.

GENERAL: I have the honor to submit the following report of a survey for the reopening of the Santee Canal, in the State of South Carolina, with an estimate of the cost of repairing it, and restoring it to a working condition, as provided for by section 2 of the act approved June 14, 1880. This work was assigned to my charge by letter dated June 17, 1880, and was executed by Capt. James C. Post, United States Engineers, who was assisted by Mr. J. H. Fisher.

The Santee Canal, located in Charleston County, South Carolina, was begun in 1793 and finished in the year 1800, under a charter granted in 1786 by the legislature of the State of South Carolina. It connects Santee River with the tidal headwaters of Cooper River, and was designed to enable the people of the northern and northeastern districts of the State to send their products to the city and port of Charleston in a convenient, expeditious, and economical manner.

The Santee is one of the principal rivers of South Carolina. It is formed by the junction of the Congaree and Wateree, in the central portion of the State. From the junction, the river flows for about 40 miles in a southerly direction, while the lower reaches take a southeasterly course to the Atlantic Ocean. Its mouth is located about 60 miles northeast of Charleston. The whole length of the river is about 180 miles. The Congaree is formed by the union of the Saluda and Broad rivers, about three-quarters of a mile above the city of Columbia. After a course of about 50 miles it joins the Wateree, being navigable for steamboats throughout its entire length. Its chief tributary, Broad River, rises in North Carolina, and is considered navigable for poleboats carrying from 30 to 40 bales of cotton for a distance of about 140 miles above Columbia.

The Wateree has a southerly course. Its length is perhaps 100 miles, and it is navigable for steamboats to the vicinity of Camden, 50 miles above its junction with the Congaree. It is formed by the confluence of Catawba River and Fishing Creek, the former having a length of about 250 miles, with its source in North Carolina. Fishing Creek is a comparatively unimportant stream.

Cooper River is a short tidal stream, flowing in a southerly course along the eastern shore of the peninsula upon which the city of Charleston is situated, and emptying into Charleston Harbor. Coasting vessels of considerable burthen can ascend to its headwaters.

From the location and comparative magnitude of the various watercourses that successively enter or form the Santee, it would seem that the Santee Canal was well calculated to furnish a desirable and conve-

nient water route to the harbor of Charleston from the interior of the State, especially from its northern central portion.

The northern end of the Santee Canal is at White Oak Landing, on the Santee River, nearly 60 miles from its mouth in a straight line, but perhaps 100 miles by river, and about 50 miles north of the city of Charleston. At this point the Santee has a width of about 270 feet, with a depth of 18 to 20 feet at ordinary stages.

Under the terms of the charter the southern terminus of the route was located at the point where Biggin Creek joins Fair Forest Creek. These creeks are also known as the West and East Branch, respectively, and their junction forms the head of Cooper River. The canal proper, however, terminated with a tide-lock on Biggin Creek, about 2 miles above that point, the remaining 2 miles being creek navigation, with not less than from 4 to 6 feet depth of water at any time. The mean rise and fall of tide at the site of the tide-lock is about 2 feet.

The whole length of the canal proper, from the first lock near Santee River to the tide-lock on Biggin Creek, is 20½ miles, of which about 5 miles constitute the summite level. The ascent from the Santee to the summit section is 34 feet, the descent from the summit to the water level at the Biggin Creek tide-lock is 69 feet. This aggregate rise and fall of 103 feet is overcome by eight single and two double or coupled lift-locks; the lifts varying from 5 feet to 10 feet.

These locks were built of brick and stone and had wooden gates. They permitted the passage of boats of 9 feet beam and 54 feet length, carrying about 20 tons of cargo on a draft of 2 feet 6 inches to 2 feet 8 inches. It appears that the canal had a towpath 10 feet wide on each bank, and that its average dimensions were about as follows, viz: width between towpaths, 35 feet; width at water surface, 32 feet; width at bottom, 20 feet; average depth of cut, about 5½ feet; depth of water, 4 feet.

The summit level of the canal was expected to derive its water supply from Kirkwook Swamp as the principal reservoir, into which could be drawn if necessary, the waters of two other reservoirs, one at the head of Greenland Swamp, the other formed by the Swamp called Bulltown Bay. To feed the next adjoining canal levels south of the summit, a fourth reservoir was formed at the head of Biggin Swamp. A small stream and some strong springs were also admitted. A number of smaller basins were provided along the lower reaches, serving either for storing water or as sidings. About 2 miles above the Biggin Creek tide-lock, the canal is crossed by the Northeastern Railroad, which runs from Charleston to Florence via Kingstree. It is also crossed by several highways.

The canal was supplied with a number of waste-wiers and flood-gates, to control the admission of feed-water and the discharge of surplus water; also with seven aqueducts to admit drainage water underneath the canal wherever necessary.

During the time when the survey was made, in October and November, 1880, the canal for a length of more than 12 miles, including the summit level, was perfectly dry. The great reservoirs designed to feed the summit level were also dry. The canal was found considerably filled up at numerous places; the tow-paths along the entire line are overgrown with trees, canes, and briers, which rendered the progress of the surveying party very difficult and tedious. At several points the banks of the canal have been cut by the owners of adjacent cultivated ands for draining purposes. Waste-weirs, flood-gates, and aqueducts. are in a dilapidated state. Two of the latter could not even be traced.

The lock chambers need some repairs, but are otherwise in a good and serviceable condition, except those of the tide-lock, which are destroyed. All the lock-gates are decayed.

The canal was opened to commerce in the year 1800, and was operated with more or less success down to the year 1840, with the exception of one interval during the years 1817 to 1819, when navigation was suspended from lack of water in the upper portions, caused by long-continued droughts. An attempt was made at that time to supply the canal with water from the Santee River by means of pumps, but it failed. From the time of the completion of the South Carolina Railroad from Columbia to Charleston, in 1840, and of the Camden Branch some years later, the canal traffic languished, and finally became so unremunerative that soon after the year 1850 the canal ceased to be operated and fell into disuse and neglect, in which condition it has remained to the present day. The subsequent construction of the Northeastern Railroad, which crosses the canal obliquely, has rendered a revival of the business on the latter still more difficult and doubtful.

In addition to the active and continued competition by the railroads, the canal suffers under another very serious disadvantage. Its history shows that from want of water it was not navigable in years of protracted drought. Previous to its construction several lines appear to have been examined for the purpose of locating a route upon which the supply of water would be ample and constant, as shown in the reports of Captain Post and Col. C. Senf, and on the parish map of the surveyor, H. Mouzon, jr., all transmitted herewith.

The expectations in this regard have not been realized, and it is impossible to remedy the evil except at great expense. The recent examination has failed to discover, within praticable distances, any new sources from which the summit level might be supplied during the dry season.

The expense of putting the Santee Canal into complete repair, but without providing for the adequate water-supply, is estimated by Assistant Fisher, who made the examination and survey under the immediate direction of Captain Post, at $76,827.95.

The details of this estimate are as follows:

To dredging 252,683 cubic yards of mud, at 25 cents	$63,170 75
To clearing 723,007 square yards, at $140 per 1,000 square yards	1,012 20
To rebuilding 22 gates, at $240	4,400 00
To rebuilding tide-lock	2,500 00
To repairing waste-ways and flood-gates	3,500 00
To repairing 21 bridges, at $25	525 00
To repairing stone and brick work on 10 locks, at $172	1,720 00
Total	76,827 95

Since this estimate does not provide for engineering and other contingent expenses, Captain Post suggests that it should be increased to $100,000; an estimate which seems to be within safe limits.

The expenditure of this sum, of $100,000 will not, however, put the canal into full working order, in the proper meaning of the term, as it will not secure any water supply.

Captain Post is of the opinion that the only practicable method of obtaining water for the canal is by pumping; but he does not recommend it, as the expense would be too great in proportion to the value of the canal, the trade of which has been absorbed by the competing railroads, and he gives therefore no estimate of the cost of securing the necessary amount of water.

The act of Congress under which the survey was made requires an estimate to be furnished of the cost of "reopening Santee Canal," and,

as such reopening necessarily implies a sufficiency of water for purposes of navigation, a consideration of the question of water-supply seems to be imperative.

There are two methods, by either one of which the canal may be rendered navigable during the driest season. *The first method* consists in lowering the summit level so that it can be fed directly from the Santee River. *The second method* consists in the application of steam-pumps, as already suggested, to keep the summit level supplied with water drawn from the Santee River.

A third method might be discussed, comprising the restoration and use of the old reservoirs to furnish water to the upper sections of the canal when sufficient drainage water is available, and the employment of steam-pumps during the dry season. But as this method does not seem to offer any advantages over that which contemplates supplying all the water with pumps, no estimates of its cost will be made. Any special merits which it may possess on the score of economy can only be determined by a minute and careful survey.

FIRST METHOD—BY LOWERING THE SUMMIT LEVEL.

The low-water level of Santee River at the starting-point of the canal, near lock I, is about 35 feet above low-water at the tide-lock near Cooper River. The surface of the water in the summit level, when filled to the proper depth of 4 feet, is 34 feet higher than the Santee. Below lock VIII, south of the summit, the water level of the canal is about 7 feet below the low-water level of the Santee. The excavation for the new summit level drawing its water directly from the river would extend nearly to that point, where a new lock of about 7 feet lift must be built. The locks now numbered IX and X and the tide-lock would be preserved or repaired, but all the other locks would be abolished. A guard-lock near the Santee would doubtless be necessary. The length of the cutting will be about 14 miles, and at many places the bottom of the new canal will be from 30 to 40 feet lower than it is at present. From a rough calculation it appears that this plan involves the excavation of about 5,000,000 cubic yards of material, which includes the construction of low banks and draining ditches on both sides of the canal to prevent the rainwater of the adjacent fields and swamps from overflowing into the canal, damaging the slopes and carrying sediment into it.

It is not known what kind of soil will be met with in making these excavations. In digging the original canal no difficulties seem to have been encountered except at one place near Biggin Creek, where a deposit of hard limestone was found, and at a few other isolated places where beds of large oyster shells and bones and tusks of some extinct species of animals had to be removed.

From the alluvial character of the region it is supposed that the digging would be generally easy; but as for several miles the cuts are quite deep, it is deemed advisable to place the cost of excavation at not less than 15 cents per cubic yard, which is assumed to include the cost of revetting a portion of the long side slopes when necessary.

Besides the necessity of building a new lift-lock and guard-lock, the plan will require the reconstruction of several bridges, of basins and yards for repairing boats, storehouses and workshops; also the acquisition of additional land. As to the cost of making the excavation 10 per cent. is added for contingencies, it is believed that the aggregate sum will approximately represent the total cost of the work.

PROBABLE COST OF THE WORK BY THE FIRST METHOD.

5,000,000 cubic yards excavated, including revetting, at 15 cents	$750,000
For locks, basins, buildings, bridges, &c	60,000
	810,000
Add 10 per cent. for engineering and incidental expenses	81,000
Total	891,000

The original estimate of the cost of the Santee Canal was £55,620, or about $278,000. In his report of November 11, 1800, Colonel Senf says that the actual expenses up to that time had exceeded double that amount. The ultimate cost, according to information received by Captain Post, was nearly four times the original estimate, or perhaps $1,100,000.

An approximate calculation shows that the volume of water abstracted from the Santee to keep the canal well supplied amounts to about 600 cubic feet per minute. The loss of so small a quantity cannot in any manner affect the river.

As will be seen further on, the probable running expenses per annum of the Santee Canal, with ten lift-locks and one tide-lock, are calculated to be $19,320. The plan here discussed requires only three lift-locks, one tide-lock, and one guard-lock, and will be more economical in that respect; but as the long slopes in the deep cuttings will require constant attention and frequent repairs, it seems to be proper to estimate the annual expense of operating the canal at not less than about $15,000.

SECOND METHOD—BY SUPPLYING THE WATER WITH PUMPS.

To make an approximate estimate of the cost of this plan, it is necessary to compute the probable quantity of water that is required for the service of the canal.

In years when navigation was suspended in the canal from want of water, it was dry for about 14 miles of its length. The pumps must be therefore powerful enough to fill a canal prism of that length, and when filled to provide for all losses from filtration, evaporation, leakage at locks, and lockage.

From observations made on canals of cross-sections similar to those of the Santee Canal, such as the Erie Canal before it was first enlarged, it may be roughly estimated that the loss from filtration and evaporation is about equal to two canal prisms per month. A canal prism of the width and depth already described and 14 miles long contains 7,687,680 cubic feet of water; and the loss from filtration and evaporation may be therefore estimated at 15,375,360 cubic feet per month.

The daily leakage at the two summit locks is estimated at twenty-four lockfuls or prisms of lift, equal to seven hundred and twenty such prisms per month. According to the description given in the report of Colonel Senf, who constructed the canal, the dimensions of each of the two summit locks (Nos. III and IV) were: width 10 feet, and length 66 feet. At lock III the lift was 9½ feet; at lock IV, 10 feet. The cubical contents of one prism of lift may be taken at 6,600 cubic feet, and the monthly loss through leakage at the locks at 4,752,000 cubic feet.

It is difficult to form an estimate of the probable expenditure of water for lockage. It is stated that during the best business year of this canal 750 boats passed through. In all probability this amount of traffic was not nearly uniformly distributed over the whole year. It is more likely that the bulk of it was done when the cotton crop was moved towards

Charleston. In the absence of better information, it is assumed that two-thirds of the whole year's business is done within three months; that if the canal could be relied upon as being always sufficiently supplied with water, at least 1,500 boats would pass through annually; and that during the busy season an aggregate of 333 boats would pass it in both directions in one month.

Allowing two lock prisms to each boat, the monthly expenditure of water for locking through 333 boats would be 4,356,000 cubic feet. The aggregate amount of water to be drawn by the pumps from Santee River during one month would therefore be as follows:

	Cubic feet.
For filling canal prism $\frac{7687680}{12}$	640,640
For filtration and evaporation	15,375,360
For leakage at locks	4,752,000
For lockage	4,356,000
Total consumption of water in one month	25,124,000

It is supposed that three pumps are employed, driven by steam-power, and placed as follows:

First pump, near lock I, Santee River, 5 feet lift; discharging into the first canal level.

Second pump, near lock II, 5,150 feet from first pump, 10 feet lift; drawing from the first level and discharging into the second level.

Third pump, near double lock III, 8,150 feet from the second pump; total lift 19 feet; drawing from the second level and supplying the summit level and adjacent reaches as far as lock VIII.

In the following calculations the prices given refer to centrifugal pumps; other varieties of pumps, may, of course, be applied.

CAPACITY OF PUMPS AND POWER OF ENGINES RUNNING TEN HOURS A DAY.

The first pump must raise during each day of 10 hours at least 837,466 cubic feet of water 5 feet high, or about 10,500 gallons per minute; engine 25 horse-power.

The second pump must raise 10,000 gallons per minute, 10 feet high; engine 50 horse-power.

The third pump must raise 9,270 gallons per minute, 19 feet high; engine 100 horse-power

The pumps may be all of the same size, the difference being only in the amount of power applied.

About 400 feet of 15-inch pipe and a dozen elbows would be required to make the connections with the upper and lower levels; the ends of pipes entering the canal will have grated guards and be otherwise protected from injury.

Each pump, with engine, boiler, and stock of fuel will be housed, and quarters will be provided for engineers and firemen.

The total cost of the pumping plant, including purchase, transportation, and setting up machinery, is estimated at $44,770, viz:

Pump No. 1, with engine and boiler	$5,000
Pump No. 2, with engine and boiler	7,300
Pump No. 3, with engine and boiler	10,500
400 feet 15-inch pipe, at $7	2,800
12 elbows, at $50	600
Pipe guards and other fixtures	1,000
Building	13,500
Add 10 per cent. for contingent expenses	4,070
Total	44,770

ANNUAL EXPENSES OF OPERATING PUMPING PLANT.

It is assumed that the whole pumping plant is in charge of a chief engineer, and that each pump with engine is attended by an assistant engineer and a fireman.

1 chief engineer, $125 per month	$1,500
3 assistant engineers, each $75 per month	2,700
3 firemen, each $50 per month	1,800
Oil, tallow, waste, and repairs	2,700
1,800 tons of coal, at $6.50	11,700
Total	20,400

The capital, the interest of which, at 6 per cent., would pay these annual expenses, is equal to $340,000.

PROBABLE COST OF THE WORK BY THE SECOND METHOD.

Repairing canal and locks	$100,000
Procuring and setting up pumping plant	44,770
Running expenses of pumping plant, capitalized	340,000
Total	484,770

OPERATING EXPENSES.

The annual expense of operating the canal, not including pumping, may be approximately computed from a statement given in Colonel Senf's report, in which he enumerates the personnel required for the work. The rates of pay are not stated in the report, but the prices given in the following table are probably not far from those that would obtain in practice.

ANNUAL EXPENSES OF OPERATING THE SANTEE CANAL, NOT INCLUDING COST OF PUMPING.

2 toll-receivers, at $900 per annum	$1,800
10 lock-keepers, at $500 per annum	5,000
10 laborers as assistants at locks, at $300 per annum	3,000
2 blacksmiths, at $500 per annum	1,000
4 carpenters and boat-builders, at $500 per annum	2,000
2 bricklayers, at $500 per annum	1,000
	13,800
40 per cent. for superintendence, tools, materials, and incidental expenses	5,520
Total	19,320

The reopening of the Santee Canal by means of a second method—the least costly of the two—cannot perhaps be regarded as inexpensive when the restricted benefits to be secured are taken into consideration. The railroads will continue to be dangerous competitors; they have proved to be so not only for this canal, but also for the navigable rivers that formerly contributed to its business. Broad River, the chief tributary of the Congaree, belongs to that class.

The transportation business of that river has much diminished since the railroads were built that run near and parallel to it, or through the districts that supplied it with freight. At the same time it may be said that an improvement of this river and of other rivers in South Carolina is urgently called for by many people interested in the transportation business, and that the ascendency of the railroads is at least in part ascribed to the many obstructions that are allowed to impede river navi-

gation, the removal of which would again attract business to these rivers. It is possible that a thorough system of improvement of all the water routes that naturally connect with the canal would tend to revive the trade on the latter. A certain advantage, however, is claimed for the railroads, peculiar to these Southern districts. Cotton, the principal staple, is in most cases raised on borrowed capital (see evidence in the report of the Senate Select Committee on Transportation Routes to the Seaboard, 1874). This capital is furnished in the form of provisions and fertilizers on which the producer has been obliged to pay, heretofore, an average of $2\frac{1}{2}$ per cent. interest per month. It is therefore of great importance to the producer to send his crops to market by the most expeditious mode he can find, and the railroad is for that reason generally preferred by him to the slower river or canal route. There can be little doubt that a thorough improvement of the canal, and of the river routes connected with it, would compel the railroads to lower their freight rates, and thus be beneficial to producers and consumers alike; and if it is not deemed important or desirable that the enterprise should be financially successful, the reopening of the canal would be followed by a revival of business on it, if the tolls are placed sufficiently low.

It is respectfully suggested that this subject should be examined in connection with the improvement of the navigation of the Congaree and Santee rivers from the city of Columbia to the ocean, and in its relations to the probable construction by the general government, at no distant day, of a continuous line of inland steamboat navigation, near the main coast, extending from Charleston in a northeasterly direction into and through North Carolina, and in a southwesterly direction into Florida.

Attention is invited to a report of an examination of the Santee River, submitted by Capt. Charles B. Phillips, United States Corps of Engineers, April 14, 1880, printed in Senate Ex. Doc. No. 161, Forty-sixth Congress, second session. The examination was made by Assistant Engineer J. M. Wolbrect.

The total length of the river from the point where it is formed by the confluence of the Congaree and Wateree, to the ocean, was stated to be 184 miles; and it was estimated that the cost of establishing a 5-foot low-river navigation from the head of the river to Wright's Bluff, a distance of about 25 miles, and a 7-foot low-river navigation from Wright's Bluff to the ocean, would not exceed about $105,000. This amount includes the cost of a canal leading into Winyah Bay, with a view of avoiding the bad bar at the mouth of the Santee.

This work is located in the collection district of Charleston. Charleston is the nearest port of entry.

The amount of duties on imports collected in the year 1879 was $24,070.

The following papers are herewith transmitted:

1. The report of Capt. J. C. Post, Corps of Engineers, U. S. A.
2. Tracing of chart of survey of Santee Canal by Captain Post.*
3. The report of Colonel Senf on the construction of the Santee Canal.*
4. General plan of the canal, accompanying Colonel Senf's report.*
5. Map of the parish of Saint Stephen, in Craven County, exhibiting several plans practicable for making a navigable canal, by Surveyor Henry Mouzon, jr.*

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Charleston, S. C., December 13, 1880.

COLONEL: In accordance with your instructions of August 2, 1880, I have to submit the following report of an examination and survey of the Santee Canal, South Carolina, made with a view of ascertaining the cost of reopening it.

This canal was constructed to connect the waters of the Santee River and its tributaries, the Congaree and Wateree, which drain nearly one-half of the northern part of South Carolina and a portion of North Carolina, with the headwaters of the Cooper River, in order to bring the city of Charleston in direct water communication with this large section of country.

When first projected a survey of five different routes was made. These were, first, from Greenland Swamp through the north branch of Biggin Swamp to Biggin's Bridge, a distance of 23 miles; second, from Greenland Swamp through the south branch of Biggin Swamp to Biggin's Bridge, a distance of 22 miles; and third, from Mattasee Lake to Wadboo Bridge, 16 miles; these three connected with the west branch of the Cooper River. The fourth route was from Savannah Creek to Huger's Bridge, 14 miles and 40 chains, and the fifth from Santee Creek to the same bridge on the east branch of the Cooper, a distance of 15 miles and 40 chains. These are given on an old map, a copy of which is inclosed herewith. According to the best information that could be obtained, this map must have been made before the war of the Revolution. No other information could be found in regard to these routes.

In 1786, a charter was granted by the legislature of the State to connect the Santee River with the Cooper River. No route was designated in the charter, but it was evidently the intention of the incorporators to take either the first or the second shown on Mouzon's map, as it was stated in the subscription paper that the proposed canal was to begin at or near Greenland Swamp. Soon after the granting of the charter the project was placed in charge of Colonel Christian Senf, a Swede, as engineer, who was at that time chief engineer of South Carolina.

He also made an examination and survey in January and March, 1787, and finally advocated a sixth route, commencing at White Oak, a few miles below Greenland Swamp, as the only one which promised a sure supply of water for the summit. This route was adopted and the canal was commenced in 1793, and completed in 1800. It was constructed 22 miles long, 35 feet wide, 5½ feet deep, and had a draw path 10 feet wide on each side. The depth of water was 4 feet. The boats in traversing the canal rose from the Santee River, in 2½ miles, 34 feet, by two single and one double lock, to the summit level, 5 miles in length, which was supplied with water from reservoirs and springs. The first reservoir, known as Kirk's Swamp, is two feet higher than the summit, and is 400 yards wide and 2,200 yards long. This was supplied with additional water by means of dams and drains from the head of Greenland Swamp, and from a second swamp known as Bull Town Bay, which were designated the second and third reservoirs respectively.

In passing from the summit level to the tide-water of the Cooper River, a distance of 14½ miles, the descent of 69 feet was made by six single and one double lock. To supply water for this portion, in addition to that received from the summit level, a fourth reservoir was formed at the head of Biggin Swamp near lock 4 at the south end of the summit level. This was expected to yield a sufficient amount for the canal between locks 4 and 8. From lock 8 to lock 9 one small stream was admitted into the canal. Below lock 9 a large and ever-flowing spring enters, and just below lock 10 Biggin Creek, a stream of considerable size, flows in. These were practically all the sources for the supply of water. Eleven locks in all were constructed, eight single and two double locks, and one tide-lock, which was placed about 1 mile above Stoney's Landing. At the locks the average rise and fall of the tide is about 2 feet. All the locks were built of brick, with wooden gates and of sufficient dimensions to permit a boat 50 feet long and 9 feet beam to pass through them. These boats carried a load of 20 tons with a draught of about 2 feet 9 inches.

The estimated cost of the canal was about £56,000, but this I am informed was increased nearly fourfold before the work was completed, including all the buildings that were erected.

A copy of Colonel Senf's final report is forwarded herewith. It gives an interesting account of the difficulties encountered during the prosecution of the work, the means employed in overcoming them, and the methods of administration adopted after its completion. This is accompanied by a copy of the general plan forwarded with his report.

From the year 1800 to 1817 there is no record to show that the canal was otherwise than successful, though it is known that it did not at any time fully meet the expectations of its incorporators. During 1817, '18, '19 there was a protracted drought which produced such a scarcity of water that the canal was dry between locks 2 and 8, a dis-

*Omitted. Printed in Senate Ex. Doc. No. 60, Forty-sixth Congress, third session.

tance of 14 miles. This led to a trial being made of filling the summit level with water from the Santee River by means of pumps. Two were purchased; one was placed at lock 2 and the other at lock 3. The first, after working for some time, barely supplied the water lost by leakage, and the second did scarcely as well. They were both soon given up.

In the following years there seems to have been generally a sufficient supply of water, and the project was fairly prosperous. During 1830, which is said to be the best year, seven hundred and fifty boats, carrying about 70,000 bales of cotton, passed through the canal, and it is said that a dividend of 15 per cent. was paid on the stock. This continued until the South Carolina Railroad was built and the Columbia Branch completed, in 1840. A few years later the Camden Branch was also completed, when the canal ceased to be used for other than local freights. Soon after the year 1850 the project had become so heavily involved that it was given up.

From all that can be learned the canal has not been used since for any purpose, except that portion between Cooper River and lock 8, and even this was only used in 1865 by some of the planters in the vicinity for bringing their produce to market.

At the present time the canal is considerably filled up; the banks are generally good, though much overgrown, and the locks, with the exception of the tide-lock, are in a fair condition, though all need some repairs. The tide-lock has been entirely destroyed and all of the gates of all the locks are decayed and valueless.

To put the canal in complete repair, Mr. T. H. Fisher, assistant engineer, who made the examination and survey, estimates that it would cost about $77,000. This does not allow any percentage for contingencies or any means for engineering labors incident to making the repairs should they be undertaken. To include these latter I would suggest that the estimate be raised to $100,000.

This amount as stated is only for what is needed upon the canal proper, and does not consider what would be necessary to give the canal a never-failing source of adequate water supply. As already mentioned, the canal failed in 1817, '18, '19 for want of water, and when the examination was made this year it was again practically dry. Kirk Swamp, the first reservoir, was also dry and planted as a cornfield, and Bull Town Bay and the head of Biggin Swamp, the third and fourth reservoirs, were about the same. Thus the canal is entirely without a water supply except for that portion from lock 8 to lock 10, which it is thought could be kept filled at small expense from the springs in the immediate vicinity already flowing into the canal.

As there are no new sources for water in the neighborhood of this work, and those now relied upon are entirely inadequate to furnish a supply in time of droughts, it will be impossible to keep the canal in continuous operation if it is reopened, except it be done by pumping. The expense of this plan, even if successful, would be so great that it cannot be recommended.

The canal nearly thirty years ago was given up because its business was taken away by the South Carolina Railroad. The condition has not improved since, but instead has grown worse, as a second railroad, the Northeastern, now crosses the canal and drains the country of its productions in the immediate vicinity. There is no new country to be developed or resources to be gained by the canal at this time, and if it could not pay its expenses in 1850 it certainly will not do so now.

This canal is located in the collection district of Charleston. Charleston is the nearest port of entry. Before closing, I desire to commend Mr. Fisher for his industry and perseverance in the prosecution of the survey.

A chart of the canal and vicinity accompanies this report.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

J 18.

EXAMINATION OF CANOOCHEE RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, November 27, 1880.

GENERAL: I have the honor to submit the following report of an examination of Canoochee River, Georgia, with estimates of cost of improvement, in accordance with the provisions of section 2 of the river and harbor act approved June 14, 1880, and assigned to my charge by letter dated June 17, 1880.

The examination was intrusted to Assistant Engineer W. G. Wil-

liamson, of Lexington, Virginia. The field work was commenced in the latter part of September, 1880, and finished in October following.

Canoochee River is the principal tributary of the Ogeechee, which it joins 5 miles above the crossing of the latter by the Savannah, Florida and Western Railroad, and about 20 miles from Ossabaw Sound. The highest point to which the examination extended was Moore's Bridge, at an estimated distance of 65 miles from the mouth of the river, measured along the water line.

The difficulty of ascending beyond Moore's Bridge in a small boat at the prevailing low stage of the river, and the apparent insignificance of these higher sections for purposes of transportation, prevented the examination from being extended above the point named.

The river is narrow, crooked, and shallow, especially in the upper reaches examined. The velocities of the current ranged from $\frac{1}{2}$ mile to $1\frac{1}{4}$ miles per hour; the depths from 1 to over 12 feet.

The upper reaches, for an estimated length of 27.8 miles from Moore's Bridge downward, have widths of from 80 to 100 feet; the middle sections for about 15 miles are from 100 to 200 feet wide, and further down to the mouth the river has widths from 200 to 300 feet.

The obstructions to navigation consist principally of snags, fallen trees, sand and rock bars, and are particularly numerous in the upper reaches of the river. As to the sand-bars, Mr. Williamson states that there are so many of them that it is almost impossible to say where one ends and the other begins, and that it would prove an endless job to remove them. The so-called rock-bars appear only in the first 15 miles reach below Moore's Bridge, and consist of compact stratified sand, resembling the sandstone from the mountains. The material is soft and easily broken *in situ*, but its removal would require blasting.

The plan of improvement suggested by Mr. Williamson essentially consists in clearing the river of snags and leaning trees, in the partial removal of rock-bars, and some cut-offs for straightening bends. He expects that these improvements will lower the sand-bars by the increased currents washing off the shifting sand and depositing it in the deeper portions of the river bed. By these improvements timber men could float their rafts safely at low-water, and boats of 12 or 18 inches draught could also pass up at that period. During somewhat higher stages of the water steamboats of 3 feet draught could run during 6 or 8 months of the year, if the five bridges spanning the river were rebuilt by the counties that own them, and furnished with draws. None of the existing bridges are higher than 15 feet above low-water.

The upper section of the river from Moore's Bridge to near Butler's Bridge, a length of about 27 miles, would be the most expensive part of the work; the lower 38 miles, to the junction with the Ogeechee, could be easily made navigable for boats drawing 3 feet, during the whole year.

The estimate given by Mr. Williamson's report contemplates the improvement of the Canoochee to such an extent that the lower 38 miles will be navigable for boats drawing 3 feet and the establishment of a minimum depth at low-water of from 18 to 20 inches in the upper reaches. The total cost he estimates at $46,094.41, including 10 per cent. for contingencies, to wit:

4 rock-bars, total length 1,350 feet, 4,588 cubic yards, at $5	$22,940 00
9 cut-offs, total length 3,625 feet, 21,887 cubic yards, at 23 cents	6,534 01
2,181 snags and fallen trees, at $5	10,905 00
1,525 leaning trees, at $1	1,525 00
10 per cent. for contingencies	4,190 40
Total	46,094 41

If the improvement be confined to the lower 38-mile reach, rendering it navigable for boats of 3 feet draught, the expense will be confined to cut-offs at five places only, and the removal of a comparatively limited number of snags and trees. The rock-bars occur in the upper sections of the river, and would not be touched. This partial improvement would cost, probably, about $9,405, to wit:

5 cut-offs, total length 625 feet, 15,000 cubic yards, at 23 cents	$3,450
900 snags (estimated), at $5	4,500
600 leaning trees (estimated), at $1	600
10 per cent. for contingencies	855
Total	9,405

The Canoochee flows through a region covered with valuable pine forests, producing timber and naval stores. Considerable business is now done upon the river in rafting timber and lumber, as well as transporting some rosin and turpentine, and the inhabitants believe that the trade would be greatly increased by some material improvement of the river. No statistics were obtainable in regard to the amount of commerce using the Canoochee route, and of the extent of country tributary to it.

This work is situated in the collection district of Savannah. Savannah is the nearest port of entry.

The amount of revenue collected at the nearest port of entry during the last fiscal year was $61,126.25.

The report of Assistant Engineer W. G. Williamson is inclosed herewith.*

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

J 19.

EXAMINATION OF ROMNEY MARSH [ROMERLY MARSHES], GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, November 15, 1880.

GENERAL: I have the honor to submit the following report of an examination of Romney (?) Marsh, with estimates of the cost of improvement, provided for by section 2, of the act approved June 14, 1880.

This duty was assigned to me by letter dated June 17, 1880.

Such examination as was deemed to be sufficient for the object in view was made by Mr. S. L. Fremont, the civil assistant on the Savannah River improvement, whose report is submitted herewith.

The water route leading through Romney Marsh, or more properly Romerly Marshes, as designated on official charts, forms part of the inland passage between the Savannah River, Ga., and the Saint John's River, Fla. These marshes are situated to the southeast of Skiddaway Island, between Wassaw and Ossabaw sounds, Georgia. They are traversed and drained by numerous tidal creeks, the most important of which, Romerly Marsh Creek, discharges into Wassaw Sound.

The surface of the marsh is uniformly level, and about 5 feet above

* Omitted. Printed in House Ex. Doc. No. 19, Forty-sixth Congress, third session.

mean low-water, so that at ordinary high tide it is entirely covered, the mean rise and fall being about 7 feet.

Vessels using the Island Passage, after leaving the Savannah River and passing down the Wilmington River, enter Romerly Marsh Creek and follow it about 3 miles; they then pass through the Romerly Marshes, following a generally southerly but very tortuous course until they emerge into Odingsell River, by which they enter Ossabaw Sound.

The objections to the existing route through Romerly Marshes are chiefly its excessive crookedness, sharp bends, and insufficient low-water depths. Vessels drawing 5 feet of water cannot pass through on less than half-tide.

The examination, therefore, had for its leading object the selection of a more suitable channel route for connecting the waters of Romerly Marsh Creek and Wassaw Sound.

Four routes suggested themselves as feasible, and they were accordingly examined. Every one of them requires more or less cutting through the marsh. The several lines are marked on the accompanying map, and will be briefly described.

ROUTE NO. 1.

This route would connect the deep waters of Romerly Marsh Creek with Odingsell River by way of "Habersham's Cut," and a required cut about 1,000 yards long through the solid marsh. This is undoubtedly the most direct route of those examined. Habersham's Cut runs about due north; it is remarkably straight, with sufficient depth and width of water for a length of over a mile. From its southern head the new cut to Odingsell River would start, and two lines are suggested for this purpose, marked on the map A-B and A-B′, respectively. Line A B or A*ab*B″, though rather longer than the other, would be probably somewhat cheaper by utilizing part of the eastern head branch of Habersham's Cut. About $1\frac{1}{4}$ miles distance will be saved by this route over the existing one.

ROUTE NO. 2.

By cutting through the marsh along the line C-D, two navigable creeks will be connected, the northerly creek emptying into Wassaw Sound at the mouth of Romerly Marsh Creek and the Southerly Creek into Odingsell River. The cost of cutting is less than for any of the other routes; but the passage through the creek is very crooked, and 3 miles longer than by the present channel.

ROUTE NO. 3.

By this line the northerly creek, mentioned above in route No. 2, would be connected with Wassaw Creek by the line of cutting C-F. Wassaw Creek flows into Odingsell River not far from the point where the latter discharges into Ossabaw Sound. It has ample accommodations for vessels using the Inside Passage. The cost of establishing this route would be about the same as by way of line A-B, Route No. 1, but the passage is very tortuous, and 3 miles longer than the channel now used.

ROUTE NO. 4.

By this route the same creeks are connected as by No. 3, but the line of canal is changed to F-G. The expense of cutting would be larger than

for any of the other lines, and it is about $2\frac{5}{8}$ miles longer than the one now used.

By Routes No. 3 and No. 4, vessels bound south on emerging from the mouth of Odingsell River could, when the sea is calm and the tide near the slack-water of flood, pass across a portion of Ossabaw Sound, thus shortening the distances above given about $\frac{3}{4}$ of a mile.

This, however, would involve waiting for the tides, which constitutes one of the principal disadvantages of the present channel. In rough weather this shorter line could not be used.

In making estimates Mr. Fremont assumes that the average depth of cutting below the surface of the marsh would be 12 feet, with a bottom width of 48 feet, and side slopes of 1 to 3, giving a low-water surface width of 90 feet. Since the surface of the marsh is about 5 feet above the low-tide level, the low-water depth in the channel would be about 7 feet. This would be ample for the class of vessels seeking this passage.

The estimated cost of the improvement on the several routes named is given below, in which the excavations are placed at 20 cents per cubic yard, and 10 per cent. is allowed for inspections and other contingent expenses.

	Cost.
Route No. 1.—Cut AB or A*ab*B″; low-water channel 7 by 48 feet	$30,272
Route No. 1.—Cut AB′; low-water channel 7 by 48 feet	35,200
Route No. 2.—Cut CD; low-water channel 7 by 48 feet	26,400
Route No. 3.—Cut CF; low-water channel 7 by 48 feet	31,680
Route No. 4.—Cut FG; low-water channel 7 by 48 feet	38,720

Another route mentioned in Mr. Fremont's report, by way of White Marsh Island and the Isle of Hope, about 3 miles west of Romerly Marshes, was examined under later instructions. By this line Skiddaway River (discharging into Wilmington River) and Burnside River (discharging into Vernon River) would be connected; the improvement consisting in deepening and straightening the very tortuous and shallow passage known as Skiddaway Narrows. The cost of this improvement would be about the same as for Route No. 1, but it is not seen that any advantage would be gained by adopting it. It appears also that this route is claimed by some parties as private property, and they are said to have obtained a charter from the State of Georgia for a toll canal.

It is not feared that the new channel will fill up again by the washing in of the excavated material placed on the banks, if the work is done with proper precautions. If a short and nearly straight route, such as that by way of Habersham's Cut, be selected for improvement, but little shoaling need be apprehended as the result of the tides dividing about half way between Romerly Marsh Creek and Odingsell River; though it is possible that some dredging may be required occasionally. With this restriction the improvement will be a permanent one.

The Inside Passage between Savannah and Jacksonville, which may be said to continue far into the interior of Florida by means of the Saint John's River, is recognized as a valuable water route for the transit of passengers. Properly improved it would furnish cheap and convenient transportation for the merchandise required, and the products of field and forest produce by a population covering an area of at least 10,000 square miles, by affording a sheltered passage to light-draught vessels that could not venture upon the outside passage. The distance between Savannah and the Saint John's River is over 200 miles, and the route traverses numerous sounds and navigable creeks and rivers, penetrating far into the interior of the coast district. Its value is emphasized when

the possibility of the United States becoming involved in war with a maritime power is taken into consideration.

For further particulars attention is invited to Mr. Fremont's report.

A local advantage is claimed for Routes No. 3 or No. 4 by way of Wassaw Creek as affording facilities for landing people seeking the seashore of Wassaw Island for health or recreation, and offers have been made to furnish aid from private sources in case a channel leading into Wassaw Creek is selected for improvement. It is presumed that the precise line to be improved need not be determined at the present time.

The estimated cost of the improvement through the Romerly Marshes, so as to give a low-water channel 48 feet wide and 7 feet deep, with side slopes of 1 upon 3, is $31,000.

The papers submitted are Mr. Fremont's report and a chart of the Romerly Marshes.*

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

J 20.

EXAMINATION OF THE MOUTH OF JEKYL CREEK, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, November 20, 1880.

GENERAL: I have the honor to submit herewith the following report of an examination of the mouth of Jekyl Creek, Georgia, with estimates of the cost of improvement provided for by section 2 of the river and harbor act, approved June 14, 1880.

This work was assigned to me under date June 17, 1880, and was carried out under my instructions by Mr. S. L. Fremont, civil assistant on the Savannah River improvement.

Jekyl Creek forms part of the inside passage between Savannah River, Georgia, and the Saint John's River, Florida. It connects Saint Simon's Sound and Brunswick River at the north with Saint Andrew's Sound at the south.

The mean rise and fall of the tide is 6.8 feet.

Jekyl Island is situated to the eastward of the creek, and separates it from the ocean.

The total length of the creek is about 5 miles. In its southern reaches, and in fact for the greater portion of its length, it has ample width and depth for the largest class of vessels that take the inside route. Toward its northern end, about a mile from its entrance into Brunswick River, a troublesome shoal exists between the points where Lathram and Mud rivers enter the creek.

From the mouth of Jekyl Creek to the deep waters of Brunswick River, in the bight formed by the southern shore of the latter, there are extensive mud flats across which vessels must pass on entering or leaving the creek.

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* Omitted. Printed in House Ex. Doc. No. 19, Forty-sixth Congress, Third session.

These two shoals form the principal obstruction to the navigation of Jekyl Creek.

The shoal between the confluences of the creek with Mud and Lathram rivers undoubtedly owes its formation and maintenance mainly to the fact that here the tides divide, except when strong and continued winds disturb the normal conditions. Another cause probably is the loss or escape of a portion of the ebb flow of Jekyl Creek through Mud River into Brunswick River. By increasing the flow of water at the "divides" it may be expected that the shoal will be reduced and that the outflow current at the mouth of Jekyl Creek will be strengthened.

In its present condition the currents in the northern portion of the creek are enfeebled by diversion into Mud River. In passing out at the mouth, its own waters meet the large volumes and strong ebb currents of Brunswick River, resulting in a bar and shallow navigation at that point. Even if a channel were made by dredging across this bar it would probably soon fill up again and require repeated dredging, as already pointed out in my report on the inside passage between Cumberland Sound and Saint Simon's Sound, Georgia, submitted April 24, 1876.

While dredging would afford temporary relief, a more feasible method for improving this entrance is indicated in Mr. Fremont's report. It consists in continuing the western bank of Jekyl Creek by means of a training-wall carried across the mud flats or bar, until the 7 or 8 feet low-water curve in Brunswick River is reached. The outer and longer portion of this training-wall, which is approximately represented on the chart by the heavy line A B, would have a northerly direction. The ebb currents of Jekyl Creek will thus be prevented from spreading out, and will join the ebb currents of Brunswick River at a favorable angle. The training-wall will also impose better conditions than now exist on the movement of the flood-tides.

This jetty or training-wall would be built of brush and stone, or of logs, brush, and stone, in the simplest manner, with a width of 14 to 18 feet; while its length, as indicated by the line A K B on the inclosed chart, would be about 2,700 feet.

It is thought that the training-wall here described will be sufficient for the object in view. If found to be otherwise, a second wall on the other side of the channel will have to be added, although its cost is not included in the accompanying estimate.

To improve the passage over the shoal in Jekyl Creek, between Mud and Lathram rivers, Mr. Fremont suggests two methods. One method consists in building a training-wall, C D, to narrow the channel and produce stronger currents. The other, which he prefers, contemplates the partial closure of the outlets of Mud and Lathram rivers, by submerged dams, E F and G H.

It appears that Lathram River is practically a tidal reservoir that feeds Jekyl Creek during ebb-tide. It is quite probable, from its location and direction of outflow, that this extra supply of water is less beneficial to the northern than to the southern reaches of the creek, where abundant depth of water prevails, although some portions of it flow out in a northerly direction.

It is different with Mud River, which has a northerly and comparatively straight course. It also connects with Brunswick River by a branch of its own, and it has been observed that portions of the ebb flow of Jekyl Creek escape through that branch and flow into Brunswick River at the point *a* on the chart.

To prevent this loss and convert Mud River, in some degree at least,

into a tidal feed basin for Jekyl Creek, a dam across the mouth of the river at the line L M appears to be desirable. If this dam produced the desired effect, the two dams recommended by Mr. Fremont at E F and G H, respectively, could be dispensed with.

The length of the dam at L M would be about 200 feet.

It is recommended to promote the action of the works described by some dredging, both over the shoal and on the bar at the mouth of Jekyl Creek. In making the estimate it is assumed that a depth of not less than 6 feet at mean low-water should be established by dredging, with a bottom width of 50 feet, and side slopes of 1 upon 3.

The length of the cut through the shoal would be a little over 3,000 feet, requiring the removal of about 18,000 cubic yards of material.

The length of the cut through the bar from the mouth of Jekyl Creek to Brunswick River would be about 1,800 feet, and 8,000 cubic yards would have to be removed.

The importance of the inside passage, of which Jekyl Creek forms a part, was briefly stated in my report on the improvement of the channel through Romerly Marshes, submitted under date November 15, 1880, to which attention is respectfully invited.

The estimated cost of the improvement of Jekyl Creek, after the method herein recommended, is $25,323, as shown below.

ESTIMATES.

1. Training-wall, mouth of Jekyl Creek, 2,700 feet, at $5.80	$15,660
2. Closure-dam, mouth of Mud River, 200 feet, at $5.80	1,160
3. Dredging shoal in Jekyl Creek, 18,000 cubic yards, at 20 cents	3,600
4. Dredging mouth of Jekyl Creek, 8,000 feet, at 20 cents	1,600
Add 15 per cent. for contingencies	3,303
Total	25,323

The report of Mr. Fremont and chart of Jekyl Creek, with location of work of improvement indicated thereon, are herewith transmitted.*

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

J 21.

EXAMINATION FOR THE OPENING OF A SHIP-CANAL ACROSS THE CHARLESTON NECK, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, November 27, 1880.

GENERAL: I have the honor to submit the following report on the examination for the opening of a ship-canal across the Charleston Neck, South Carolina, provided for in the act of Congress approved June 14, 1880.

This duty was assigned to me by letter from the office of the Chief of Engineers, United States Army, dated June 17, 1880.

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* Omitted; printed in House Ex. Doc. No. 19, Forty-sixth Congress, Third session.

The examination was conducted by Capt. James C. Post, United States Corps of Engineers, whose report is herewith transmitted.

Charleston Neck is a narrow peninsula, extending down into Charleston Harbor in a southerly or slightly southeasterly direction, and is bounded on the west side by Ashley River and on the east side by Cooper River and a branch of the same called Town Creek.

The average width of the neck for a length of six miles, measured from the extreme point in the harbor, is about $1\frac{3}{4}$ miles, and the rivers on both sides for this entire distance, and still higher up, are navigable for vessels of deep draught, with bold shores generally favorable for the construction of wharves and piers.

The city of Charleston occupies the lower extremity of the neck, on the harbor. The present wharves extend on Cooper River a distance of about $1\frac{3}{4}$ miles and on Ashley River a distance of about 2 miles, from the extreme southerly point of the Neck.

There is therefore a long unoccupied water-front, bordering on streams of ample depth, on each side of the Neck adjoining the built-up portion of the city and within the "city limits."

The wharves on Ashley River are scattered and infrequent, nearly all the shipping business of the place being transacted on the Cooper River.

The railroad business of the place is transacted by three lines, to wit, the Northeastern Railroad, having a northern and western connection by way of Florence; the South Carolina Railroad, extending to Columbia; and the Savannah and Charleston Railroad to Savannah, with a western connection at Yemassee, by way of Port Royal Railroad. The Northeastern Railroad possesses wharfage facilities of moderate capacity on Cooper River, and the Savannah and Charleston Road has the same on the west bank of the Ashley River, at a point where its bridge-crossing formerly existed. The track of the South Carolina Road does not reach tide-water at any point. Its depot in the city is a trifle over $\frac{3}{4}$ of a mile from deep water.

The location selected by Captain Post for the ship-canal crosses the peninsula on a straight course, running south $78\frac{1}{2}$ degrees west from Town Creek to Ashley River, at a distance measured on a normal right line of $2\frac{7}{8}$ miles from the southerly point of the Neck. It lies outside the built-up portions of the city. On the line suggested, the length of the canal would be 10,550 feet.

The line of the canal will of course cross that of the South Carolina Railroad, as well as that of any other road which may hereafter enter the city by way of Charleston Neck.

It will be observed that Captain Post does not advance any reasons why this work should be undertaken at the expense of the United States, nor does he mention any of the objects sought to be attained, and the advantages to general commerce and navigation to be derived from it, beyond a simple reference to a letter from General B. H. Rutledge, embodying a discussion by that gentleman of this branch of the subject.

From the views expressed in General Rutledge's letter, and from statements both written and oral received from other sources, it is believed that the object soughts to be attained by the construction of this canal may be classed under four general heads, as follows:

1. That the canal will establish close connections between sea-going vessels and all railroad lines now entering or which may hereafter enter the city of Charleston by way of the Neck, thus supplementing the improvement of the outside bar now in progress, which would otherwise be incomplete in its beneficial results.

2. That the construction of this canal will place the railroad connections directly at the sea, and thus develop the trade and commerce of Charleston, and benefit the interior and the great West by supplying a convenient shipping port, open at all seasons of the year and possessing excellent terminal facilities.

3. That the canal will facilitate the construction and lessen the cost of the works of improvement on the outer bar, by enabling the United States to procure stone from the quarries near Columbia, S. C.

4. That the canal, if built by the United States, will or may afford free wharfage, thus releasing the shipping interests from the wharf-charges now imposed by the individuals or private corporations owning the present wharves in the city of Charleston.

With respect to the plan now being carried out for improving the ocean approach to Charleston Harbor, at the outer bar, it is respectfully submitted that when that plan was prepared in this office the works necessary for forming close and convenient connections for handling freights in the city of Charleston, either by digging a canal to the railroads, or by extending the railroad tracks to the water, or by any other method, were considered to be mere details of terminal facilities, which those charged with the carrying business would provide as soon as it became their interest to do so The same view is entertained now, and no case is remembered where the general government has charged itself with such local matters.

The sole object of the improvement of the outer bar was, and is, to establish a safe and convenient channel by which deep-draught vessels can enter and leave the port of Charleston and discharge and receive their cargoes in quiet water at the wharves of the city. There is no reason to doubt that this result will be attained at a cost somewhat below the original estimate of $1,800,000.

The cost of these works on the main bar would, no doubt, be lessened in some slight degree by improving the facilities for handling railroad freights at Charleston, so that stone could be brought in the required quantities from the quarries near Columbia and delivered to scows or lighters directly from the cars.

The Northeastern Railroad is doing this now, under a contract to transport the stone from Columbia to the wharf at Charleston for $1.50 per gross ton. Freights on stone from New York to Charleston have ranged from $1.45 to $1.75, or an average of $1.60 per gross ton.

The gain, therefore, is comparatively small, not exceeding about 4 per cent. of the total cost of stone from New York delivered on the works.

It seems proper to state that, so far as work on the harbor improvements is concerned, a slip or basin of suitable capacity for the service of lighters, excavated from Ashley River to the track of the South Carolina Railroad, at a cost of $15,000 to $20,000 at the outside, would answer quite as well as the ship-canal. A branch track to deep water could, perhaps, be laid for a less sum, and would accommodate large vessels.

It would seem, indeed, that when the South Carolina Railroad shall have extended its tracks to deep water—and it is understood to be its intention, as it obviously is to its interest, to do so, unless deep water is brought to its tracks—all the substantial advantages of the much-needed close connections between ships and railroads will have been fully secured, inasmuch as the other railroads already possess wharfage facilities.

The present wharf-charges, however, would still remain, and it is admitted that a release from them is very desirable. One question in this

connection is, ought the general government to be charged with its achievement? Another is, would free wharfage be achieved by the construction of the canal?

The plan for this canal, prepared by Captain Post, is believed to be both comprehensive and feasible, and well adapted to the special objects in view, to-wit, convenient facilities for the interchanging of freights between railroad-cars and ships.

The legislature of South Carolina has appropriated the sum of $15,000 towards its construction. This sum is now at the disposal of the canal commission created by the same authority, and preliminary steps have already been taken for excavating a slip from Ashley River to the line of the South Carolina Railroad, for the service of lighters to be used in conveying stone to the jetties on the outer bar.

ESTIMATED COST OF THE CANAL.

For a canal of 20 feet depth at mean low-water, a bottom width of 200 feet, side slopes of 1 upon 1, and tide gates at each end, and placing the cost of excavations at 11 cents per cubic yard, the additional cost of filling on the banks at 6 cents, the masonry of all kinds at an average of $9.50 per cubic yard, and 4 iron tide-gates at $3,000 each (all reasonably low prices), the estimated cost of construction, allowing 10 per cent. for engineering and contingent expenses, amounts to $439,789.

This does not include the cost of the right of way, and of the necessary railroad and highway bridges over the canal.

It is respectfully suggested as a preliminary and prudential measure to be adopted, preferably at the present stage of this enterprise, that the following questions should receive careful and intelligent consideration by a board or commission of engineers, or such other competent source of information as may be conveniently available:

1st. Shall the local facilities usually provided at the maritime termini of railroads be secured in the city of Charleston by digging a canal across the railroad tracks, or by extending those tracks to the unoccupied water-fronts of the city?

2d. If the canal shall be found to offer any advantages, and Congress shall appropriate money to build it, the following points, and, doubtless, many others, seem to require careful attention before the work is begun, in order that complications growing out of the use and maintenance of the canal may be avoided as far as possible.

1. Who shall furnish the right of way?
2. At whose expense shall the canal be operated and maintained?
3. Shall there be a right of way free to all on each side of the canal; and, if so, who is to furnish it and prescribe its width?
4. Shall parties owning lands on either side have the exclusive use of the canal bank along their water-front; and, if so, upon what terms?
5. Shall storehouses be erected on the banks of the canal; and, if so, upon what terms?
6. If storehouses are erected, who is to fix the storage rates?
7. What precautions, if any, can be taken to prevent the storage rates from becoming as burdensome as the present wharfage rates?

The following papers are herewith transmitted.

1. The report of Capt. J. C. Post, Corps of Engineers, U. S. A.*
2. A sheet of drawings showing a profile along the line of the canal, and a map, on a smaller scale, of Charleston Neck.*
3. A copy of the act of the legislature of South Carolina, providing for the con-

struction of a canal in the city of Charleston, approved December 23, 1879; also copy of an act amendatory thereto, approved February 19, 1880.*

4. A letter from General B. H. Rutledge, to Capt. J. C. Post, dated Charleston, November 18, 1880.*

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

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*Omitted. Printed in House Ex. Doc. No. 19, Forty-sixth Congress, Third session.

APPENDIX K.

IMPROVEMENT OF THE HARBORS OF MOBILE, ALABAMA, AND OF PENSACOLA AND CEDAR KEYS, FLORIDA; OF TAMPA AND APALACHICOLA BAYS, FLORIDA, AND OF CERTAIN RIVERS IN GEORGIA, ALABAMA, FLORIDA, AND MISSISSIPPI EMPTYING INTO THE GULF OF MEXICO.

REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, BVT. MAJOR, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., August 25, 1881.

GENERAL: I have the honor to transmit herewith annual reports for the year 1880–'81, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

K 1.

IMPROVEMENT OF THE HARBOR AT MOBILE, ALABAMA.

The improvement of the channel of Mobile Harbor by the general government was begun in 1827, and up to 1857 the amount of $228,830.60 had been appropriated.

The work done was the dredging of a channel 200 feet wide and 10 feet deep through "Choctaw Pass Bar," and the partial dredging of a channel through "Dog River Bar," 10 feet deep, with width unknown.

The depth, prior to the commencement of the improvement in 1827, was 5½ feet on the latter, and on the former bar 8 feet. In 1860, the cut through "Choctaw Pass Bar" had shoaled to 7½ feet, while that through "Dog River Bar" had remained unchanged. From 1870 to 1875, the amount of $401,000 was appropriated to further improve the channel to a depth of 13 feet, and the work done was the dredging of a channel 13 feet in depth and 200 feet wide through "Dog River Bar," and 13 feet deep with a width of 300 feet through "Choctaw Pass Bar," and all soundings since that date indicate no perceptible change in depth on either bar.

By act of Congress approved June 18, 1878, $10,000 was appropri-

ated for the purpose of making tests, surveys, and borings, in order to determine whether the present 13-foot channel could be so deepened, and the depth maintained, as to admit to the wharves of the city vessels drawing not more than 22 feet. The result of these surveys was a report to the Chief of Engineers suggesting several different plans of improvement. It was finally decided to continue the work on the old plan, viz, the dredging of the then existing 13-foot channel to a depth of 17 feet with a width of 200 feet from the 17-foot curve in the Mobile River to the same curve in the lower bay.

The estimated cost of the improvement is		$820,000 00
Appropriations are as follows:		
Act approved March 3, 1879	$100,000	
Act approved June 14, 1880	125,000	
Act approved March 3, 1881	100,000	
		325,000 00
Amount required for completion		495,000 00

Congress, by act approved March 3, 1879, having appropriated $100,000 for this improvement, bids were called for and opened on May 20, 1880. Five bids were received, the lowest being 24 9/10 cents per cubic yard, and this being deemed excessive, all were rejected and the work ordered to be readvertised.

Congress, in the mean time, by act approved June 14, 1880, appropriated $125,000, and bids were therefore called for on a basis of $225,000 and were opened on August 20, 1880.

The lowest bid was 12 3/10 cents per cubic yard. Eight bids were received, the lowest bidder being Messrs. George C. Fobes & Co. (see abstract of bids hereunto attached). The contract was awarded to them at 12 3/10 cents per cubic yard, and the date of commencement fixed for December 29, 1880. At that date they were not prepared, and were granted an extension to February 1, 1881, but owing to the severity of the winter, they were still further delayed to February 19, 1881. At that date the dredge (clam-shell) was placed in position and the work started.

The contractors were much delayed from various causes, and did not get fairly under way before the middle of March.

The following is a statement of material removed from February 19, 1881, to June 30, 1881:

	Cubic yards.
Cut No. 1, 3.50 miles long, to Black Buoy No. 5	128,172
Cut No. 1, .57 mile long, above Lower Gap light	14,977
Total..... 4.07 miles in length	143,149

Each cut is 35 feet in width and with minimum depth of 17 feet.

The material removed is a stiff, tenacious clay mixed slightly with shell; shows no tendency to wash. In some portions of the cut for a distance of 1,000 feet a depth of 20 feet has been reached, and the sides of the cut remain as dug, the bottom indicating no change in form or depth when soundings were taken two months after.

The minimum depth of 17 feet has been maintained throughout the portion dredged, except at one point, at the entrance from channel into Mobile River. Here the cut has been refilled for a distance of 1,640 feet by the sand flowing in from the east.

The same trouble was met with when dredging the 13-foot channel, but as soon as it was opened to full width, this tendency ceased, and it is believed that the same will result with the 17-foot channel.

I regret to state that the dredging has not been prosecuted with that energy on the part of the contractors necessary to insure the completion

of the contract within the time specified, but they give assurance of such increase of force as will be sufficient to comply with the terms of the contract. There now remain only seven months of the twelve months' time contracted for, and I may say hardly a commencement has been made. The channel has been staked out with piles, 500 feet apart, as far as Buoy No. 3, a distance of 8½ miles.

Bids for continuing the dredging according to project adopted have been called for and will be opened July 9, 1881, under the appropriation of $100,000 made by act of Congress approved March 3, 1881. It is proposed to apply the funds now available for expenditure during the fiscal year ending June 30, 1882, to continuing the present project, viz, deepening the 13-foot channel to full 17 feet at mean low-tide.

It is proposed to expend the appropriation asked for for fiscal year ending June 30, 1883, in continuing the same.

The amount necessary to carry out the present project to completion, exclusive of all former appropriations, is estimated at $495,000, and this amount could be most profitably expended in one year, as it would be to the true interest of the government, as well as to the city of Mobile, to have the channel opened as soon as possible.

The abstract of bids in former portion of report clearly shows that large amounts draw competition, and thereby reduce the price per cubic yard, in this case of over one-half.

There is but one point throughout the entire length of 27½ miles where the bottom is of such a character as to suggest a doubt as to the permanence of the improvement, viz, at the mouth of the Mobile River, already referred to. It is impossible for even an approximate estimate to be made at this time of the probable amount and extent of this filling, consequently no estimate has been made as to the amount of annual appropriation that will probably be required. In any event it will be small, and, compared with the importance of the work, insignificant.

The position of Mobile on the Gulf of Mexico is such that she must become in time a very important port for the traffic between the West Indies and South America, on the one hand, and the great Northwest of this country on the other. Unbroken railroad connections with Chicago, Saint Louis, Cincinnati, Louisville and other cities of the Northwest, and also with the Pacific coast, now exist, and furnish the four millions of people of that vast section of the Union with the productions of this traffic in less time and at less cost than through any of the ports of the Atlantic coast.

The mineral resources of this State are unlimited. The iron and coal deposits are easily accessible for distribution by the great river system, and Mobile, by means of this system discharging into the Bay of Mobile, is the nearest and most available point of shipment.

The expense of the improvement would be repaid if it only resulted in supplying the government with a coaling station where fuel of excellent quality and at low rates could be had at all seasons of the year, and would prove of incalculable value in the event of a maritime war. It would therefore seem that the improvement is one of national importance, and not local, directly benefiting the Northwest and South, and not merely the port of Mobile and State of Alabama.

The work is situated in the collection district of Mobile, and Mobile is the port of entry, and is located in the Bay of Mobile, extending from the mouth of river of same name to the "Lower Anchorage," a distance of 27½ miles.

The accompanying statistical statement of the commerce of Mobile for the fiscal year ending June 30, 1881, has been furnished by the collector of customs.

Money statement.

July 1, 1880, amount available	$224,884 00	
Amount appropriated by act approved March 3, 1881	100,000 00	
		$324,884 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	21,575 72	
July 1, 1881, outstanding liabilities	947 07	
		22,522 79
July 1, 1881, amount available		302,361 21
Amount (estimated) required for completion of existing project		495,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		200,000 00

Abstract of bids received and opened August 26, 1880, relating to dredging in Mobile Harbor, Alabama.

No.	Name of bidder.	Price per cu. yd.	Time of commencing work.	Time of completing work.
1	Wm. A. Alexander	$0 15.85	3 months after notification of approval of contract.	1 year from date of commencement.
2	Jas. E. Slaughter	14.6	3 months after notification of approval of contract.	Do.
3	O. J. Jennings	19¼	3 months after notification of approval of contract.	Do.
4	American Dredging Company.	23	4 months after notification of approval of contract.	1 year after notification of approval of contract.
5	National Dredging Company.	13	3 months after notification of approval of contract.	1 year from date of commencement.
6	Geo. C. Fobes & Co	12.3	3 months after notification of approval of contract.	Do.
7	Jas. G. Stewart	19.4	3 months after notification of approval of contract.	Do.
8	Geo. Kellogg	19⅛	Not specified	Not specified.

COMMERCIAL STATISTICS.

Duties on imports	$226,116 59
Tonnage dues	16,854 00
Hospital collections	2,803 77
Miscellaneous	12,407 74
Total collections, 1881	258,182 10
June 30, 1880	63,946 09
Increase	194,236 01
Value of exports to foreign ports	6,594,840
Value of exports to foreign ports, 1880	6,219,818
Increase	375,022
Imports of foreign goods, 1881	659,397
Imports of foreign goods, 1880	430,297
Increase	229,100

Entrances and clearances at the port of Mobile.

ENTRANCES.

Arrivals.	June 30, 1881.			June 30, 1880.		
	Vessels.	Tonnage.	Crew.	Vessels.	Tonnage.	Crew.
Foreign	99	69,019	1,492	62	40,422	893
Coastwise	57	20,606	376	87	24,925	704
American	40	14,982	454	68	22,075	591
Totals	196	104,607	2,319	217	87,422	2,196

CLEARANCES.

Foreign	72	64,679	1,384	71	35,949	1,009
American	54	18,690	497	85	23,930	700
Coastwise	46	17,777	400	54	18,686	453
Totals	172	101,146	2,281	210	78,565	2,162

The Mobile Cotton Exchange furnishes the following statistics of the business of the port of Mobile for 1880–1881:

COTTON RECEIPTS.

	1881.	1880.
Alabama River ..... bales	46,262	46,572
Tombigbee River ..... do	66,967	77,151
Warrior River ..... do	15,600	15,479
M. & O. Railroad ..... do	160,622	176,384
M. & M. Railroad ..... do	95,314	38,490
Totals ..... do	384,765	354,076

Coffee importations, 17,395 sacks.

NAVAL STORES.

	1881.	1880.
Rosin ..... barrels	154,837	143,509
Turpentine ..... casks	22,549	25,109
Tar ..... barrels	400	250
Pitch ..... do	2,500	2,500

Statistics of exports from Mobile, via the rivers, as furnished by the agents of the various lines.

VIA WARRIOR AND TOMBIGBEE RIVERS.

	Quantities.	Value.
Lumber ..... feet	4,500,000	$45,000 00
Shingles ..... number	350,000	750 00
Merchandise ..... tons	128,150	3,003,000 00
Cotton seed, corn, oats, coffee, &c ..... sacks	600,925	1,124,006 00
Lard, bacon, and pork ..... hogsheads, casks, and barrels	22,546	1,567,478 00
Soap and candles ..... boxes	7,200	36,000 00
Flour, sugar, molasses, whisky, &c ..... hogsheads and barrels	128,403	1,598,946 00
Bagging and ties ..... bundles and rolls	33,866	201,400 00
Total value	.....	7,576,580 00
Receipts, passage money	.....	40,000 00
Receipts of freight money	.....	296,493 00
Value of boats	.....	97,000 00
		8,010,073 00
Via the Alabama and tributaries	.....	4,006,036 00
Total estimated value via rivers	.....	12,016,109 00

Comparative table of lumber and timber shipments to foreign and coastwise ports for 1880 *and* 1881.

	1881.	1880.
Lumber:		
Foreign ..... feet..	11, 531, 246	11, 168, 030
Coastwise ..... do...	9, 587, 562	5, 404, 198
Per rivers ..... do...	4, 500, 000	.....
Timber:		
Foreign ..... cubic feet..	1, 693, 838	745, 279
Coastwise ..... do...	10, 986	.....
Shingles:		
Foreign ..... number..	3, 900, 250	4, 689, 200
Coastwise ..... do...	216, 000	200, 000
Staves, foreign ..... do...	91, 462	121, 460
Laths, coastwise ..... do...	256, 000	.....

	1881.	1880.
SALT.		
Imported from Liverpool direct ..... sacks..	77, 627	42, 566
Imported from Liverpool indirect ..... do ...	7, 000	32, 000
Imported coastwise, Vermillion Bay ..... do ...	18, 011	None.
Other points ..... do ...	2, 000	12, 548
Total ..... do ...	104, 638	87, 114
MISCELLANEOUS.		
Alabama coal ..... tons..	8, 189	5, 396
Pennsylvania and English coal ..... do...	2, 701	1, 033
Fish and oysters ..... value..	$185, 000	$150, 000
Vegetables ..... do...	159, 706	174, 483
Wool ..... do...	348, 532	325, 786

K 2.

IMPROVEMENT OF PENSACOLA HARBOR, FLORIDA.

By act of Congress approved June 18, 1878 an appropriation of $20,000 was made for the improvement of this harbor, including survey and estimate for the removal of wrecks.

These wrecks, four in number, having been previously located, their removal was commenced during the fall of 1878 and completed in December, 1879.

The survey of the entrance to Pensacola Harbor, for the purpose of ascertaining the extent and probable cause of the shoaling of the main ship-channel south of the Middle Ground, was made during the fiscal year ending June 30, 1879. For full report of same, with my recommendation for further improvement, I would respectfully refer to the Annual Report of the Chief of Engineers for 1879, Appendix J 2, page 801.

This report was referred to the Board of Engineers for Fortifications and River and Harbor Improvements, who expressed their views and recommendations in their report to the Chief of Engineers under date of February 12, 1881.

By act of Congress approved June 14, 1880, an appropriation of $40,000, and by act of Congress approved March 3, 1881, $20,000 was made for this improvement, making, with the unexpended amount from former appropriations, the sum of $70,000 available for this work. In accordance with instructions from the Chief of Engineers, and recom-

mendations of the Board of Engineers, the following project was submitted for its expenditure, under date of May 4, 1881:

1. To construct Jetty A, in front of Fort McRee; plans and specifications for same to be prepared and submitted for approval.

2. To apply $30,000 of the funds applicable to deepening the channel through the inner bar, across the main channel (as indicated in the inclosed sketch at *a'' a' a*), to a depth of 24 feet at mean low-water, and as wide as the amount available will permit, not exceeding 300 feet.

The cut to be located after making the necessary soundings, as recommended by the Board of Engineers.

3. To retain the balance of the amount applicable as a reserve for use in shore protections, in case of scour caused by the construction of Jetty A.

This project, having been approved by letter of Chief of Engineers, dated May 16, 1881, limiting the amount to be expended on Jetty A to $26,000, a surveying party, under the immediate charge of Mr. H. Haines, was organized in April, 1881, for the purpose of determining the location, length, and plan of Jetty A, with estimate of its cost, and also to determine the proper location of the channel to be dredged through the bar in main channel.

Location and plan of jetty having been approved by the Chief of Engineers, advertisements for proposals of bids for construction of jetty, and dredging through inner bar in main channel, were advertised for under date of June 9, bids to be opened July 9, 1881.

The appropriation of $75,000 asked for for fiscal year ending June 30, 1883, it is proposed to expend in constructing necessary shore protections south of Jetty A, and in widening the dredged channel to 300 feet, in accordance with recommendations of the Board of Engineers.

Until the works as contemplated are completed, and their effectiveness ascertained, no estimate of the cost of the work required to make the improvement permanent can be submitted.

The inner bar across the main channel is a great obstacle to the commerce of this port, as it causes loss of time and considerable expense to vessels having to wait days, and sometimes weeks, before a sufficient depth of water on the inner bar will permit them to go to sea.

The removal of this obstruction will permit this port not only to retain its already large trade, but no doubt to considerably increase it; it will also enable our vessels of war to reach Pensacola navy-yard without detention.

This work is located in the collection district of Pensacola, Fla., and Pensacola is the nearest port of entry.

STATEMENT OF NATURE AND VALUE OF EXPORTS FROM PENSACOLA, FLA., DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

	Value.
4,232,205 cubic feet hewn timber	$550,316
6,200,174 cubic feet sawed timber	806,022
77,119,000 feet B. M. lumber	1,079,666
9,421 bales cotton	376,840
Total exports	2,812,844

Five hundred and nine vessels cleared, with a tonnage of 303,910 tons.

The amount of revenue collected at this port can only be given from December 1, 1880, to June 30, 1881 (the records prior to former date having been destroyed by fire), and said amount is $80,732.44 for the seven months.

Money statement.

July 1, 1880, amount available	$53,098 07	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$73,098 07
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		3,486 60
July 1, 1881, amount available		69,611 47
Amount (estimated) required for completion of existing project		104,470 52
Amount that can be profitably expended in fiscal year ending June 30, 1883		75,000 00

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 19, 1881.

SIR: I have the honor to submit herewith a report from the Board of Engineers for Fortifications and for River and Harbor Improvements, upon the improvement of the entrance to the harbor of Pensacola, Fla.

It was stated in the last annual report of this office, with reference to the application of the appropriation of $40,000 for this improvement in the river and harbor act of June 14, 1880, that a project had been received from Capt. A. N. Damrell, Corps of Engineers, in charge, which had been referred to this Board for consideration, and that it would be made the subject of a special report.

The annual report of this office of October 20, 1879, drew attention to the changes that had taken place by the abrasion of the western-shore line of the entrance in the vicinity of Fort McRee, and the formation of an inner bar in the main ship-channel; also, to the recommendation of the engineer officer in charge, to endeavor to restore the old shore line at Fort McRee by a brush or stone dike, or jetties, and to the deepening of the channel through the new bar by dredging; a project which he estimated would cost about $177,000.

As it was, doubtless, with the view to some improvement of this kind that the appropriation of 1880 was made, the present project of Captain Damrell for the expenditure of the above appropriation was for the purpose of carrying out this plan as far as funds would admit.

The Board of Engineers, whilst not looking upon the restoration of the former lines of the west shore as a necessity, is of opinion that the shore should be protected from further abrasion in order to preserve a site for batteries for defensive purposes, as well as to arrest the lateral movement of the channel, which leads to the formation of a deposit across it, and recommends that a cut be made by dredging through the recent deposit at the entrance to the harbor, and to hold the west shore by jetties of brush mattresses and stone; and designates the position, number, and size of the jetties that may be required, as also, approximately, the position of the cut to be made by dredging. The cost of the whole project is set down at $150,000.

I beg leave to suggest that the recommendations of the Board be approved, and that Captain Damrell be instructed to proceed with the

work as far as funds will admit, in strict conformity to the views and suggestions of the Board, as indicated in this report.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen., U. S. A.

Hon. ALEXANDER RAMSEY,
Secretary of War.

[Indorsement.]

Approved.
By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

FEBRUARY 24, 1881.

REPORT OF THE BOARD OF ENGINEERS.

OFFICE OF THE BOARD OF ENGINEERS FOR FORTIFCATIONS,
AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, February 12, 1881.

GENERAL: This Board, to which was referred, by your letter of 6th July, 1880, the project of Captain Damrell for improvement of Pensacola Harbor, Florida, has the honor to submit its views thereon as follows:

The entrance way to Pensacola Bay, Florida, lying between the west end of Santa Rosa Island and the main shore opposite, is about a mile in width. Middle Ground Shoal divides its channel, pressing the deeper water towards Fort McRee, while the swash channel flows in close proximity to the island. The bar $1\frac{3}{4}$ miles outside of the forts connects with the south shore of Santa Rosa Island, through East Bank, and with the west beach, through Caucus Shoal. At low-water, so far as our records go, it has always admitted vessels of 22 feet draught.

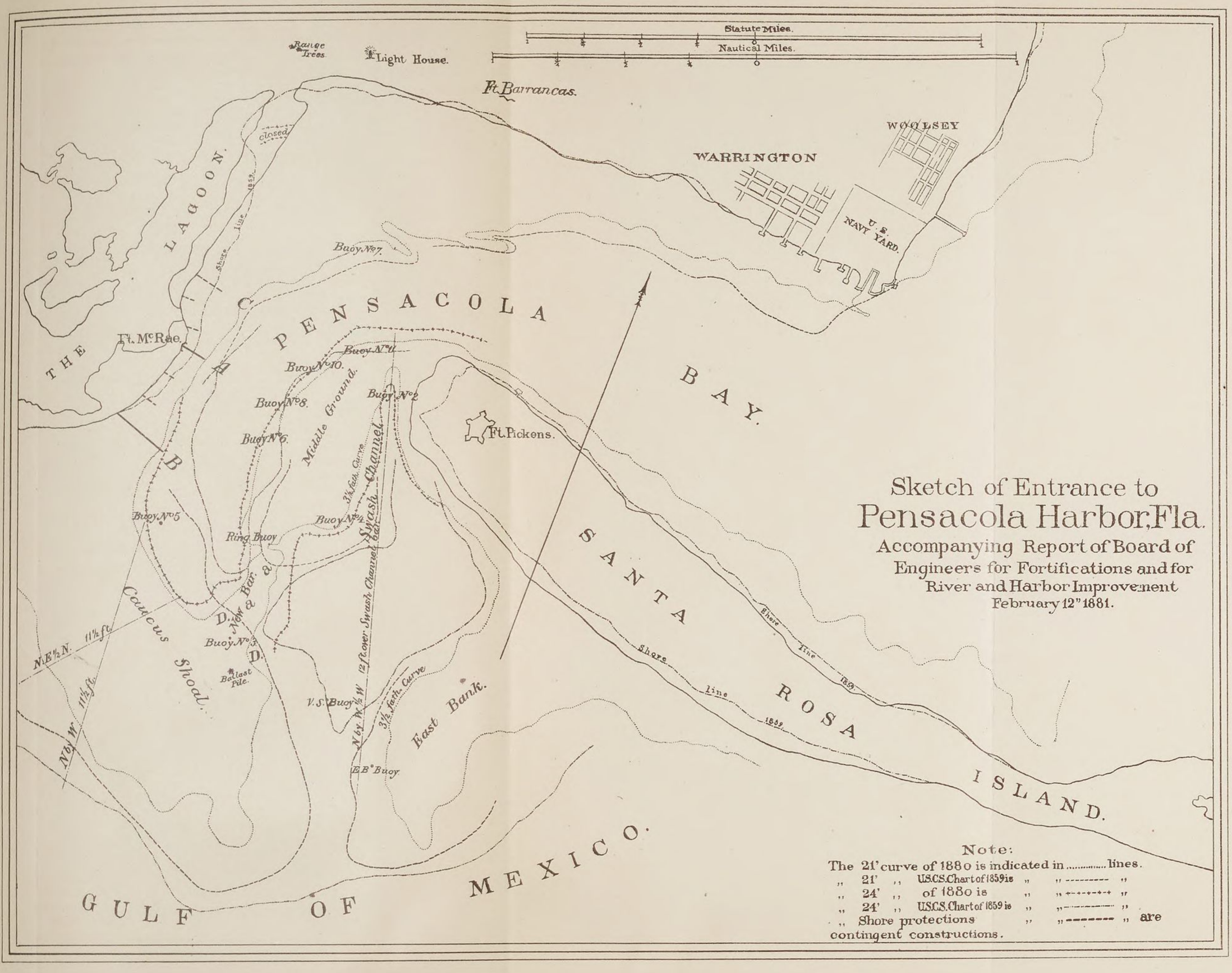
Until recently a greater depth was obtained in the channel inside of the bar. But at this time the Middle Ground has stretched southerly to unite with the east end of Caucus Shoal by a sand deposit, reducing the channel depth from 4 fathoms to 21 feet, with a tendency to further obstruction if the cause be not arrested.

To comprehend more fully this channel disturbance, it will be necessary to refer to its past progress, so far as the maps in our possession furnish information in reference thereto. Now we know that as early as 1855 the main shore had been so much abraded as to expose the foundations of the pan coupé of Fort McRee. The Coast Survey chart of soundings of 1856 shows a deposit between the Middle Ground and Caucus Shoal, with least depth of 19 feet upon it, and leaving but a narrow channel on either side, giving 24 feet water. Between the years 1855–'60 the work of restoring the McRee shore was prosecuted by means of short jetties, which proved effectual in reforming the beach to a certain extent. As these jetties, however, did not extend down to the bottom of the channel, they were gradually undermined, and finally disappeared from view. We have no soundings to show their effect upon their channel, but doubt if their length was sufficient to restore its normal condition. At any rate the Coast Survey chart of 1864 shows the same deposit in the channel-way as above noticed, marked by a buoy with an indicated depth

of 19½ feet, but apparently connected with the Middle Ground. Since that date the western shore has been receding with a constant progress until the low-water line has reached the gateway at the rear of Fort McRee, the masonry of which has nearly all fallen down by being undermined. The 24-foot channel curve has moved west and south from 400 to 500 feet on the channel side of Caucus Shoal. But this change has not been carried to the east end of the shoal, as both the 24 and 21 foot bottom curves sweep around to the north and join the Middle Ground. It would seem that the outflowing water reaching this deep bend has not sufficient eroding power to cut through the compact formation of the shoal, except by a slow abrasion, and that the living force of the portion turned eastward is too far checked to remove the deposit which now obstructs the channel.

In the absence of detailed current observations and frequent surveys which would reveal the lesser alterations in the channels of entrance to Pensacola from year to year, we can reason in a general way only upon those more marked changes indicated at long intervals by Coast Survey maps, and by the recent observations made by the engineers on this station. There can be little doubt that Santa Rosa Island, originating probably in a sand-bar outside of the great indentation known as Pensacola Bay, has, by accretions at its west end, extended in that direction from the date of its formation, and as in progress of time the water-way has become very much compressed, the opposite shore must have given way to make tidal room. This process is now fully established, and the form of the channel from the bay to the gulf necessitates its continuance. Since the condition of the channel becomes less favorable with this receding movement of the west shore, it seems necessary, as a preliminary step, to arrest that movement. If the west shore can be fixed, remedial measures may be instituted to recover the former depth of water in the channel, though it seems probable that the progress of the erosion already made in a westerly direction will somewhat change its lines in approaching and crossing the bar. Now, whether the recent deposit shown at A A A, accompanying sketch, be in part formed from the sands thrown in over the bar in storms, and in part by erosion of the inner shore of Santa Rosa and the channel slope near the Fort Pickens wharf, or be produced mainly by abrasion of Fort McRee beach, it is evident that its removal cannot be expected by tidal action without turning upon it the outflowing current in its full force. If the 21-foot and 24-foot channel lines along the Caucus Shoal be noted in accompanying chart, as represented for the years 1856 and 1879, it will be perceived that both of these curves have traveled so far westward and southward that to pass over what was the channel twenty years ago would require a diversion of the current almost at right angles from its direction opposite Fort McRee. The above bottom curves are still making progress into the Caucus Shoal, as is evidenced from recent examinations, and the accretions on the deposit at A are gathering.

It seems quite probable that if the inner shores were efficiently protected from erosion, that the ebbing current would, in time, cut through Caucus Shoal, giving a new channel corresponding to the present lines of shore. But the commercial interests of Pensacola will not rest content with a less depth of channel than was formerly maintained. To restore that depth at once, dredging will be needed, the direction of the cut being taken to deviate as little as possible from the central channel line as now established. To hold the west shore may require three jetties, possibly aided by short shore protections. The first of these to be



Sketch of Entrance to Pensacola Harbor, Fla.

Accompanying Report of Board of Engineers for Fortifications and for River and Harbor Improvement February 12th 1881.

Note:

The 21' curve of 1880 is indicated in ..... lines.
" 21' " U.S.C.S. Chart of 1859 is " " - - - - - - - - "
" 24' " of 1880 is " " + - + - + - + - + "
" 24' " U.S.C.S. Chart of 1859 is " " ———— "
" Shore protections " " ——— " are contingent constructions.

built (formed of brush mattresses and stone) should be projected from the beach at the site of Fort McRee A, and should reach down to the 4-fathom curve at least. The other jetties north and south of the first, located on map only approximately, will be determined in position and length by the effect produced in the progress of the first. Of these, that at B seems most needed to control direction of the ebb, so that the dredged channel may be maintained, and preparations should be made to commence it soon after jetty A, if this latter in its progress so disturbs the outflow as to indicate a necessity for shore protection beyond it. Jetty at C may not be needed.

In conclusion, the Board are of opinion that the west shore of the entrance to Pensacola Bay should be protected from further abrasion, for the following reasons:

First. The preservation of a site for batteries needed for defensive purposes. This is a matter the more important that Pensacola has a navy-yard to be protected in addition to its valuable commercial interests, and that it is a good harbor of refuge on the Gulf.

Second. To arrest the movement westward and southward of the channel, which by turning too abruptly the ebbing current as it approaches the Cancus Shoal checks its flow and leads to the formation of a deposit from Middle Ground across the channel.

The Board further recommends that a cut be made by dredging through the recent deposit at the entrance of the harbor approximately on a line, DD, with the suggestion, however, that the local engineer should determine its position more accurately by a succession of current observations in the immediate vicinity.

From our consultation with Captain Damrell, charged with the improvement of the Alabama and Florida coasts, we think $50,000 should be made available for the above dredging; $50,000 for the construction of jetty C; and $50,000 for commencing additional jetties, whose exact location will be determined as the progress of the first structure in connection with the results of the dredging reveal their necessity.

It should be remarked in this connection that we do not look upon the restoration of the former lines of the west shore as a necessity. The jetties will doubtless prove satisfactory if they succeed in holding the present lines against existing causes tending to cut them away. They therefore should be extended and multiplied no further than is needed to preserve the west shore as it is now.

As brush and stone jetties have for many years been in use for river and harbor improvements, we limit ourselves to a few suggestions as to the general features of those recommended for the entrance to Pensacola Harbor.

One part by volume of stone to two of brush will doubtless be ample to consolidate these jetties and to give them strength to withstand shocks of waves to which they will be exposed. An average of 15 feet width at top, with side slopes of 2 upon 3, and a more gentle batter of the end towards the channel, are indicated as a basis for these constructions. It may be necessary to spread the jetties laterally in connection with the shore and to raise them several feet above high water, to prevent the destructive effect of waves running along the beach obliquely and breaking against and over their shore ends.

This shore protection is largely an experimental problem, to be wrought out by close study and observation of the engineer in charge of this improvement.

Accompanying chart (1) shows approximate positions of jetties and

shore protections as well as present and past condition of entrance channel and bar as indicated thereon by two sets of bottom curves.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers and Bvt. Maj. Gen.
JOHN NEWTON,
Colonel of Engineers and Bvt. Maj. Gen.
HENRY L. ABBOT,
Lieutenant-Colonel Engineers and Bvt. Brig. Gen.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

K 3.

IMPROVEMENT OF HARBOR AT CEDAR KEYS, FLORIDA.

Provision was made for the survey of this harbor by act of Congress approved June 10, 1872.

The plan adopted for the improvement was to dredge a channel 200 feet wide and as deep as the underlying limestone would permit, not exceeding 12 feet, through the "Outer Bar" and the "Middle Ground" between "Way Key" and "Depot Key," and to make slight improvements in the channel.

The original depth of the Outer Bar was 8½ feet, and width 1,250 feet.

The Middle Ground was originally above water at very low tide. The estimated cost of the work was $133,500.

The amounts appropriated are as as follows:

Act approved June 10, 1872	$7,500
Act approved March 3, 1875	15,000
Act approved August 14, 1876	10,000
Act approved June 18, 1878	20,000
Act approved March 3, 1879	15,000
Act approved June 14, 1880	15,000
Total appropriated	82,500
Estimated cost	133,500
Appropriations	82,500
Unappropriated balance	51,000

The first appropriation was expended in dredging by contract on the Outer Bar.

The second, in the same place, in the same manner.

The third was applied to dredging a cut through the Middle Ground and Outer Bar, and making slight improvements in the main channel between Sea Horse and Harbor Keys.

The fourth was applied to completing the cut through the Middle Ground and to the Outer Bar.

The fifth, in removing the wreck of the steamer Lewisburg, and widening the dredged channel through the Outer Bar.

At the beginning of the present fiscal year dredging operations on the Outer Bar were continued by the contractor, Mr. James E. Slaughter, until August 15, 1880, when, the appropriation being exhausted, work was suspended, after 12,636 cubic yards of material had been removed.

The project of expending $15,000, appropriated by act of Congress

approved June 14, 1880, in completing the cut through the Outer Bar, and in deepening the channel between the bar and the railroad wharf, having been approved, advertisements for proposals for dredging were published September 9, 1880, and on October 9, 1880, three bids were received and opened (abstract of same appended). Mr. James E. Slaughter, the lowest bidder, at 67 cents per cubic yard, was awarded the contract.

Under this contract dredging in the channel through the Outer Bar was resumed in February, 1881, and continued until April 21, 1881, when the work had to be suspended, the appropriation being exhausted; 21,332 cubic yards of material were removed during that time.

The results obtained up to the close of the fiscal year ending June 30, 1881, are a cut 200 feet wide and 11½ feet deep (down to the limestone) through the Middle Ground; another, 200 feet wide and 12 feet deep, through the Outer Bar, excepting at a point 80 feet from the line of the black buoys, where the limestone is 11½ feet under the surface, the remaining 120 feet, on the east side of the cut, being fully 12 feet deep.

The main channel, between Sea Horse and Depot Keys, has also been improved by removing a shoal of mud and shell at Buoy No. 7.

There being no appropriation by last Congress for this work, there are no funds for further improvement. Should the next Congress make one, it should be used in the removal of two beds of unstratified limestone in the reach of main channel, between Buoys Nos. 7 and 8, where the depth is 10½ feet, and another bed of the same character at Buoy No. 10, where the depth is 9½ feet. This last calls most urgently for improvement by excavation; it is 80 yards long, and extends entirely across the channel. It will require the entire amount of the remainder of the estimate for completing this project—$51,000—perhaps more, to remove these limestone shoals. Should, however, the rock work be laid aside for the present, the next most pressing is the dredging and straightening the channel from Piney Point, a mile west of the wharf at Cedar Keys, to the northwest channel north of North Key, which is the direct entrance to Cedar Keys from the west and from the Suwanee River.

A width of 100 feet and a depth of 10 feet will answer for the present.

To accomplish this work $40,000 will be necessary.

The cut through the middle ground has somewhat filled in next to its banks by the storms of the past two years; $2,000 will be sufficient to remove the sand and put it in better condition than before.

The shoal of mud and shell which existed in the main channel near Buoy No. 7 may occasionally require dredging; 200 yards of which had accumulated during the storms of 1880–'81 were, during the past year, removed.

Cedar Keys is located in the collection district of Saint Mark's, and is a port of entry.

The town is the Gulf terminus of the Atlantic and Gulf Transit Railroad. It has no connection with the mainland by any other road.

From the office of the collector of customs the following commercial statistics were obtained:

Value of receipts from foreign ports	$4,930
Value of exports	$21,095
Total number of vessels entered	167
Tonnage of same	125,900
Total number of vessels cleared	126
Tonnage of same	86,567
Amount of revenue collected	$9,326
Value of pine and cedar lumber shipped	$352,000

Before this work was begun the tonnage was scarcely worthy of notice.

The population of the town has more than doubled in the past three years.

The freight receipts during the year are more than double those of any previous year.

The establishment of passenger and freight lines from New Orleans and Pensacola has called more general notice to the locality. Those routes having comparatively easy access to the wharf, are availed of by tourists from the West and Northwest and afford convenient and direct transit for western produce of all kinds, which is distributed along the coast and far into the interior.

This commerce has so greatly increased that the railroad authorities have found it necessary to increase their wharf capacity.

Two new saw-mills, one for cedar, the other for pine, add materially to the local business. The fish and oyster business is more than doubled; the same with the semi-tropical fruit trade.

New houses and stores are in course of erection; merchants are generally enlarging their stores to meet the improving business. Mail lines have been established to points along the coast—Crystal River, Bayport, Clear Water Harbor, Manatee, Tampa, Key West, and up to the Suwanee River.

This prosperity is in a great measure due to the harbor improvement.

No appropriation is asked for for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$26, 649 43
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	26, 447 46
July 1, 1881, amount available	201 97

Abstract of bids received and opened October 9, 1880, relating to dredging in Cedar Keys Harbor, Florida.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	Jas. E. Slaughter	$0 67	March 1, 1881.	July 1, 1881.
2	Wm. A. Alexander	0 68	Eight months.	Fifteen months.
3	Geo. C. Fobes & Co	0 68	Not given.	Not given.

K 4.

IMPROVEMENT OF CHATTAHOOCHEE RIVER, GEORGIA.

The survey of this river, directed by acts of Congress approved March 3, 1871, and June 10, 1872, was made from Columbus to Chattahoochee, Fla. The preliminary report was submitted July 31, 1872.

The final report was submitted in the annual report from this office for the fiscal year ending June 30, 1873, and forms a part of the annual report of the chief of engineers for that year.

The present project for the improvement of this river was adopted in 1873, and contemplated making a channel 100 feet wide and 4 feet deep at low-water, to be accomplished by using jetties and wing-dams

for the sand and gravel bars, removing snags wherever necessary, and widening and deepening the rock shoals by blasting. Work was commenced in the summer of 1874, and continued during the low-water seasons. The channel was badly obstructed with snags, sand-bars, and marl-reefs, giving a low-water depth of from 1 to 3 feet, and a width of from 35 to 500 feet. Between the bars and rock ledges were deep pools needing no improvement.

The following tabular statement, furnished by the assistant in charge, shows the width and depth of each bar and shoal before and after improvement, and its condition on the 30th of June, 1881; also the progress made during the fiscal year ending June 30, 1881:

Names of places.	Miles below Columbus, Ga.	Miles below Eufaula, Ala.	Miles above Eufaula, Ala.	Miles above Fort Gaines, Ga.	Original depth, feet.	Present depth, feet.	Original width, feet.	Present width feet.	Work done during the year ending June 30, 1881.			
									Snags removed.	Overhanging trees cut.	Linear feet jetty built.	Linear feet jetty repaired.
Abercrombie's Bar	8	....	77	....	1	4	350	150	.....	.....	54	.....
Woolfolk's Bar	10	....	75	....	1⅓	4	500	150	.....	.....	208	1,023
Upatoie Bar	11	....	74	....	2	4	300	150	.....	.....	.....	.....
Shell Creek Bar	24	....	61	....	3	3	350	350	.....	.....	.....	.....
Little Uchee Shoal	17	....	68	....	2	4	50	60	.....	.....	.....	.....
Reef below Uchee Shoal	17½	....	67½	....	1½	4	50	60	.....	.....	.....	.....
Slick Bluff Reef	18	....	67	....	0	4	39	55	.....	.....	.....	.....
Middle Rocks	18½	....	66½	....	1½	4	30	100	.....	.....	.....	.....
Big Uchee Shoals	19	....	66	....	1½	4	35	65	.....	.....	.....	.....
Culpepper Island	32	....	53	....	2	4	400	150	.....	.....	110	.....
Hardridge's Shoal	....	27	....	6	2	4	35	100	.....	.....	.....	.....
Between Columbus and Chattahoochee.	....	....	....	....	....	....	.....	.....	295	51	.....	.....
Total	....	....	....	....	....	....	.....	.....	295	51	372	1,023

Names of places.	Work done during the year ending June 30, 1881.						Remarks.
	Linear feet drilled.	Number of blasts made.	Average charge powder, pounds.	Cubic yards rock removed.	Barges built.	Steamboats repaired.	
Abercrombie's Bar	.....	.....	....	.....	....	....	Contracted with wing-dams.
Woolfolk's Bar	.....	.....	....	.....	....	....	Do.
Upatoie Bar	.....	.....	....	.....	....	....	Do.
Shell Creek Bar	.....	.....	....	.....	....	....	Shore protection.
Little Uchee Shoal	.....	.....	....	.....	....	....	Rock blasted.
Reef below Uchee Shoal	.....	.....	....	.....	....	....	Do.
Slick Bluff Reef	.....	.....	....	.....	....	....	Dry-reef blasted.
Middle Rocks	.....	.....	....	.....	....	....	Rocks removed.
Big Uchee Shoals	.....	.....	....	.....	....	....	Do.
Culpepper Island	1,064	232	4½	1,769	....	....	Contracted with wing-dams and marl-reef removed.
Hardridge's Shoal	.....	.....	....	.....	....	....	Rocks removed.
Between Columbus and Chattahoochee	.....	.....	....	.....	....	....	
Total	1,064	232	4½	1,769	2	1	

By act of Congress approved March 3, 1881, an appropriation of $20,000 was made for continuing this improvement, and it is proposed

to apply the funds available for expenditure during the fiscal year ending June 30, 1882, as follows:

For the improvement of Francis Bar, by blasting a channel through the marl reef on the Alabama side of the island.

To remove land slides and snags from the channel between Chattahoochee, Fla., and Columbus, Ga., and to employ the blasting boats in removing the rock obstructions at Cody's, Betton's, Uchee shoals, Averett's, Baltimore and Oak Log shoals, and Roanoke Island and Cowackee reefs.

The proposed application of the appropriation asked for the fiscal year ending June 30, 1883, is the completion of the above project, to keep the works in repair, and to remove such obstructions as may be precipitated into the channel by the winter freshets.

I am satisfied that the former estimates for the completion of these works of improvement are inadequate, for the following reasons:

A large portion of each appropriation has been spent in the preservation of the works already completed, and in repairing the damage done by the winter freshets, which have been unusually disastrous the past season.

Many hundred snags have been lodged in the channel, and large and numerous land slides have occurred all along the river banks.

These changes cause the banks to cave and wash in other places, and add to the immense quantity of gravel and silt brought down by every freshet, to form new bars and add to the old ones. I do not believe $50,000 added to the former estimates will be any too much, thus making the amount estimated required for completion of the works $115,000.

The improvements will not be permanent when completed, and I would increase the annual estimate for their preservation, and for the removal of snags, land slides, and other contingencies from $3,000 to $10,000 for an indefinite period.

The amount that can be profitably expended during the fiscal year ending June 30, 1883, is $75,000.

As will be seen from the accompanying statistics, the river traffic has very much increased during the year.

For 1881 the total value of merchandise	$5,787,140 00
For 1880 the total value of merchandise	4,398,000 00
Increase for last fiscal year	1,389,140 00
Or about 31 per cent.	
River freights for 1881 aggregate	265,960 00
River freights for 1880 aggregate	196,800 00
Increase for last fiscal year	69,160 00
Or about 30 per cent.	

From the previous annual increase of commerce, it is reasonable to expect it to grow from year to year as the improvements advance, and offer better facilities for transportation.

The commerce interested consists mainly in cotton and such agricultural produce as are grown upon the alluvial river lands, and such general merchandise as is required by an agricultural people. As to what extent the navigation has been benefited, I can only cite the fact that the boats have been able to make the regular weekly trips to and fro from Columbus during the entire year, when in former times, before the improvements were commenced, they not unfrequently laid on some sand bar for weeks at a time, waiting for a rise in the river.

The work is situated in the collection districts of Savannah, Brunswick, and Saint Mary's, Ga., and Savannah is the nearest port of entry.

The amount of revenue collected for the fiscal year ending June 30, 1881, is $367,980.76.

The following table of statistics has been furnished me by the board of Port Wardens of Columbus, Ga.:

From points on river to J. P. & M. R. R., 16,930 bales cotton, at $50 per bale	$846,500 00
From points on river to J. P. &. M. R. R., 7,400 barrels, at $7 per barrel	51,800 00
From points on river to A. & G. R. R., 17,200 bales cotton, at $50 per bale	860,000 00
From points on river to A. & G. R. R. & Bainbridge, 19,600 barrels, at $7 per barrel	137,200 00
From J. P. & M. R. R., to points on river, 15,420 barrels, at $7 per barrel	107,940 00
From A. & G. R. R., to points on river, 79,640 barrels, at $7 per barrel	557,200 00
From Apalachicola and intermediate points to all points above, 37,390 barrels, at $7 per barrel	261,730 00
From Eufaula to all points below, 53,460 barrels, at $7 per barrel	374,220 00
From Eufaula to all points below, 1,730 bales cotton, at $50 per bale	86,500 00
From Eufaula to all points above (Columbus), 2,100 bales cotton, at $50 per bale	105,000 00
Received at Columbus from river, 25,846 bales cotton, at $50 per bale	1,292,300 00
Received at Columbus from river, 18,200 barrels, at $7 per barrel	127,400 00
From Columbus to points below, 82,700 barrels, at $7 per barrel	578,900 00
From Columbus to points below, 7,859 bales cotton, at $50 per bale	392,950 00
Mules and cattle shipped (in value)	7,500 00
Receipts from passage to boats	42,000 00
Receipts from freight	223,960 00
Value of boats employed	45,000 00
	6,098,100 00

In addition to a large commerce, the subjoined table will show the extent of her manufactories.

Names.	Spindles.	Looms.	Hands employed.	Bales consumed per annum.	Value production per annum.	Capital.	Remarks.
Eagle & Phœnix Manufacturing Company	44,000	1,500	1,600	14,000	$1,450,000	$1,250,000	Cotton and wool.
Columbus Manufacturing Company	4,500	130	165	1,700	.....	263,000	Cotton.
Muscogee Manufacturing Company	4,000	80	125	1,500	250,000	157,000	Do.
Steam mill	2,000	.....	41	500	45,000	30,000	Do.
A. Clegg & Co	.....	36	30	.....	.....	10,000	Do.
Hinde & Preer	.....	15	50	.....	.....	30,000	Bagging.
Columbus Iron Works	.....	.....	250	.....	.....	100,000	Iron, &c.
Steam Plow Company	.....	.....	18	.....	.....	23,000	lows, &c.
Empire Mills	.....	.....	13	.....	.....	50,000	6 burrs, 250 barrels flour, 11,200 bushels meal per diem.
Totals	54,500	1,761	2,292	17,700	1,745,000	1,913,000	

Eufaula, Ala., being the next city of importance on this, river I subjoin a copy of a letter received from Mr. J. O. Martin of that place:

EUFAULA, ALA., *May* 2, 1881.

DEAR SIR: * * * After summing up with the assistance of some of our best business citizens, I reply to your inquiries as follows:

1. Population of Eufaula	6,000
2. Value of real estate	$1,750,000
3. Annual cotton receipts	50,000
4. Annual sale of merchandise	1,500,000
5. Banking capital (more needed)	250,000

6. Manufactories:

Flour mills, 10 run	$30,000
Sash, door, planing mill	10,000
Carriages, &c	20,000
Other minor manufactory interests	10,000

7. Value of commerce by improving river, 25 to 40 per cent.

In fact the value of permanently improving the Chattahoochee River would be to Eufaula inestimable.

Very respectfully, yours, to command,

JNO. O. MARTIN.

Money statement.

July 1, 1880, amount available	$37,204 66	
Amount appropriated by act approved March 3, 1881	200,00 00	
		$57,204 66
July 1, 1881, amount expended during fiscal year exclusive of outstanding liabilities July 1, 1880		18,245 30
July 1, 1881, amount available		38,959 36
Amount (estimated) required for completion of existing project		115,000,00
Amount that can be profitably expended in fiscal year ending June 30, 1883		65,000 00

K 5.

IMPROVEMENT OF FLINT RIVER, GEORGIA.

This improvement was commenced below Bainbridge, Ga., in November, 1877, and has been carried up to Hell Gate, 22 miles above Bainbridge. The project contemplates the opening of a channel 100 feet wide and 3 feet deep at low-water, by the removal of snags, loose bowlders, and blasting solid ledges. The original depth on the shoals was from 6 to 3 feet, and the width varied from 30 to 100 feet. The present low-water depth to Hell Gate is 3 feet, and width 100 feet. During the three and one-half years that this work has been in progress, 58 miles of river have been opened, from its mouth up stream.

To accomplish this, twenty-two shoals have been worked on. An act of Congress approved June 18, 1878, directed an examination of this river between Albany and Montezuma, Ga. The report of this examination was submitted February 6, 1879, and is contained in the Annual Report of the Chief of Engineers for year ending June 30, 1879. The project adopted for this portion of the river was to remove snags and overhanging trees, to give a navigable channel for light-draght steamers at a medium stage of water.

An allotment was made, from the appropriation for improving Flint River, Georgia, approved June 14, 1880, of $10,000 for the improvement of Flint River, Georgia, between Albany and Montezuma, and a snag-boat 60 by 24 feet, and a quarter barge, were built, and work commenced near Drayton, Ga., in March last.

There are 24 rock shoals on this part of the river, for which no estimate has been made. The improvements above are practicably useless until these shoals are removed, so as to give a continuous channel through to Albany.

The following table, furnished by the assistant in charge, exhibits the condition of the improvement on June 30, 1881:

Names of places.	Miles below Bainbridge, Ga.	Miles above Bainbridge, Ga.	Miles above Chattahoochee, Fla.	Miles below Newton, Ga.	Original depth, feet.	Present depth, feet.	Original width, feet.	Present width, feet.	Remarks.
Lambert's Island	12	....	24	....	1	3	0	100	New channel opened west of island.
Rob's Rock	10	....	26	....	0	2	60	100	Dry bowlder not finished.
Broad Axe Rock	9½	....	26½	....	½	4	50	100	Bowlder in mid-channel.
Bryant's Rock	4½	....	31	....	½	4	70	100	Bowlder on point.
Versailles Rock	2	....	34	....	0	4	50	100	Bowlder in mid-channel.
Bainbridge, Ga.	0	..	36	....	1	4	100	100	Several rocks near wharf.
Fodder Stack Shoal	....	12	....	30	0	4	80	100	Dry ledge removed to widen channel.
Cross Chute	....	11	....	31	0	4	75	100	Do.
Below Cross Chute	....	4	....	38	½	4	30	100	Loose rocks removed.
Three Rock Reach	....	3	....	39	½	4	40	100	Do.
Winding Shoals	....	22	...	20	1	4	40	100	Loose rocks and solid ledge.
Crawford's Point	....	21	....	21	0	4	70	100	Dry ledge removed to widen channel.
Below Crawford's Point	....	12 to 21	....	21 to 30	1	3	40	100	Ten reefs of loose rock and solid ledges not estimated for in Hodge's survey.

Progress made during fiscal year ending June 30, 1881.

Names of places.	Miles below Newton, Ga.	Miles above Bainbridge.	Linear feet dam built.	Number snags removed.	Linear feet drilled.	Number blasts made.	Average charge powder, lbs.	Cubic yards rock removed.	Original width, feet.	Present width, feet.	Original depth, feet.	Present depth, feet.	Remarks.
Winding Shoals	20	22	390	3	31	10	4	456	40	100	1	4	Loose rocks and solid ledge.
Crawford's Point	21	21	....	10	312	101	...	739	70	100	0	4	Solid ledge.
Below Crawford's Point	21 to 30	12 to 21	....	43	829	253	....	1,198	40	100	1	3	Loose rock and solid ledge.
Total	....	....	390	56	1,172	364	....	2,393	....	....	...	....	

The following is a summary of work on Flint River between Albany and Montezuma, during the fiscal year ending June 30, 1881:

1 snag-boat, 60 by 24 feet, built and equipped.
1 quarter boat, 30 by 12 feet, built and equipped.
Snags removed, 697.
Overhanging trees cut, 549.

By act of Congress approved March 3, 1881, an appropriation of $15,000 was made for this river, under which it is proposed to commence work at Hell Gate and continue the same on up stream as far as the appropriation will allow, adhering to the original project of improvement of 1873.

The appropriation for Flint River, Georgia, between Albany and Montezuma, Georgia, will be expended in removing snags between Drayton and Montezuma, Ga.

The proposed application of the appropriation asked for the fiscal

year ending June 30, 1883, is to continue the work up stream as far towards completion as the funds will permit.

The amount, exclusive of former appropriations, required for the entire completion of the work is $167,829.52.

These improvements are nearly permanent, and an annual expenditure of $2,000 for five years after their completion is deemed sufficient for their preservation.

The amount that can be profitably expended during the next fiscal year, ending June 30, 1883, is $75,000.

No practical benefit has yet been derived from these improvements above Bainbridge, Ga., and none will be realized until Newton is reached, and the full benefits will only be reaped when navigation is opened to Albany, Ga. During the past winter a small steamer was built at the latter place as a pioneer. There is a large agricultural country tributary to the river, and I have no doubt but that a large business will be built up as soon as the condition of the river will justify it. The commerce on that portion below Bainbridge has increased about 30 per cent. over the fiscal year ending June 30, 1880, and is likely to continue to increase from year to year.

The traffic consists principally of guano and miscellaneous northern freights, delivered at Bainbridge by the Atlantic and Gulf Railroad, and carried by boats to points along the Chattahoochee River.

The work is situated in the collection districts of Brunswick and Saint Mary's, Ga. Apalachicola, Fla., is the nearest port of entry.

The amount of revenue collected for the last fiscal year is $2,686.65.

The cotton crop for the year 1879–1880 in the counties adjacent to Flint River amounted to 167,082 bales, valued at $6,700,000. The value of real and personal property in these counties is estimated at $31,241,492.

Money statement.

July 1, 1881, amount available	$22,867 52	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$37,867 52
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		15,892 68
July 1, 1881, amount available		21,974 84
Amount (estimated) required for completion of existing project		167,829 52
Amount that can be profitably expended in fiscal year ending June 30, 1883		75,000 00

K 6.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

This improvement was commenced in 1874; the project adopted being to secure a navigable channel of 6 feet depth by the removal of snags and sunken logs, and widening and straightening the channel through Styx River and Moccasin Slough, so as to abandon 6 miles of the old river which had ceased to be navigable. The river generally furnishes sufficient width and depth.

The condition of the improvement at the close of the year shows that in addition to having removed the snags and improved Styx River and Moccasin Slough so as to compare favorably with other portions of the river, Styx Island has been demolished, and Chipola Cut-off opened for a distance of 9 miles, giving good stream navigation to the orange

groves along Dead Lake, and opening up communication with Chipola River.

The following tabular statement exhibits the progress made during the fiscal year ending June 30, 1881:

Names of places.	Miles below Chattahoochee, Fla.	Miles above Apalachicola, Fla.	Snags removed.	Overhanging trees cut.	Cubic yards blue clay removed.	Original width, feet.	Present width, feet.	Original depth, feet.	Present depth, feet.	Remarks.
Moccasin Head Cut-off.....	89	47	.....	....	1,349	0	70	0	5	Canal cut across peninsula washing.
Styx Island.....	91	45	.....	....	884	80	200	0	6	Island cut down.
Chipola Cut-off.....	81	55	86	16	.....	50	100	15	15	Snags, &c., removed.
Between Apalachicola and Chattahoochee, Fla.....	....	....	566	8	.....	....	.....	....	....	
Total.....	....	...	652	24	2,233	....	.....	...	....	

By act of Congress approved March 3, 1881, an appropriation of $1,500 was made for this improvement, with which it is proposed to keep the river free from snags and other obstructions during the fiscal year ending June 30, 1882.

The proposed application of appropriation asked for the fiscal year ending June 30, 1883, will be to keep the works already complete in repair, to remove the annual accumulation of snags, and, if found necessary, to improve Bluntstown Bar by a system of wing-dams. If the river and harbor improvements are to be worked as auxiliaries, I would suggest the propriety of devoting the unexpended balance of the estimate to closing some of the sloughs that make out from the river between Saint Mark's River and the port of Apalachicola, so as to concentrate more water on the river bar at the latter place and utilize it to deepen the channel by scour.

The amount estimated required for the completion of the improvement, exclusive of former appropriations, is $43,500, and is deemed sufficient for the entire completion of the work, which will not be entirely permanent. An annual expenditure of $2,000 will be sufficient to keep the works in repair and the river clear of snags, &c.

Amount that can be profitably expended in fiscal year ending June 30, 1883, $25,000.

In consequence of railroad competition and a lack of sufficient depth of water on the Apalachicola Bar, the commerce had dwindled down to a mere local trade, but the improved navigation above, with the prospect of deeper water on the bar, has somewhat revived it.

During the fiscal year a steamer has been running between Apalachicola and New Orleans, and several thousand bales of cotton have been shipped in that way.

Two new mills have been erected in Apalachicola, and two near East Pass, making five saw-mills, with a capacity of about 200,000 feet of lumber per day.

The shipment of fish and oysters has largely increased, but in the absence of statistics, for which I have applied, I cannot give precise figures.

The work is situated in the collection district of Apalachicola, Fla., and Apalachicola is the nearest port of entry.

The amount of revenue collected during the fiscal year ending June 30, 1881, is $2,686.65.

The following statement of entrances and clearances of vessels at the port of Apalachicola was furnished by the collector of customs:

ARRIVALS.

	Vessels.	Tons.
Coastwise	33	7,556
Foreign	11	2,841
Total	44	10,397

CLEARANCES.

	Vessels.	Tons.
Coastwise	41	9,773
Foreign	8	2,290
Total	49	12,063

Vessels owned in district, 39.

Money statement.

July 1, 1880, amount available	$5,905 39	
Amount appropriated by act approved March 3, 1881	1,500 00	
		$7,405 39
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		3,165 81
July 1, 1881, amount available		4,239 58
Amount (estimated) required for completion of existing project		43,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		25,000 00

K 7.

IMPROVEMENT OF APALACHICOLA BAY, FLORIDA.

The survey of this bay was made in 1871, and a re-examination in December, 1878, based upon which, the plan to dredge a channel through the bar at the mouth of the Apalachicola River, 100 feet wide and 11 feet deep at mean low-water, was adopted.

The present minimum depth of water over this bar is $3\frac{1}{2}$ feet. By act of Congress approved June 14, 1880, an appropriation of $10,000 was made for this improvement, and advertisements for proposals for bids for dredging were published September 9, 1880, and opened on October 9, 1880. (An abstract of the bids is hereunto annexed.) The contract was awarded to Mr. W. A. Alexander, at $46\frac{3}{4}$ cents per cubic yard.

Under this contract work was to have commenced May 24, 1881, but an extension of time was granted the contractor, until September 24, 1881; consequently no work was done on this improvement during the present fiscal year.

An additional appropriation of $10,000 was made for this improvement by act of Congress approved March 3, 1881, which it is proposed to expend in continuing the dredging of a channel 100 feet wide, and 11 feet deep at mean low-water, through the bar at the mouth of the Apalachicola River. Proposals for this work published June 9, to be opened July 9.

The estimated cost of dredging this channel is $100,000, of which $80,000 yet remains to be provided for, and which amount could be

profitably expended during the fiscal year ending June 30, 1883, in completing the proposed channel.

The improvement when completed would not, probably, be permanent; no dredging having been done so far, the amount required to be expended yearly cannot be estimated.

This work is situated in the collection district of Apalachicola, Fla. Apalachicola, Fla., is the nearest port of entry.

For statistical statement of present and prospective trade of Apalachicola principally to be benefited by this improvement, I respectfully refer to my report on Apalachicola River.

An appropriation of $80,000 is asked for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		401 11
July 1, 1881, amount available		19,598 89
Amount (estimated) required for completion of existing project		80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		80,000 00

Abstract of bids received and opened October 9, 1881, relating to dredging in Apalachicola Bay, Florida.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	S. N. Kimball	$0 50	Ten days	One year.
2	Jas. E. Slaughter	49	Not given	September 1, 1881.
3	Wm. A. Alexander	46.75	Six months	One year.

K 8.

IMPROVEMENT OF TAMPA BAY, FLORIDA.

The examination for this improvement was provided for by act of Congress approved June 18, 1878, and extended from Egmont Key, at the entrance to Tampa Bay, to the wharves at Tampa on the Hillsborough River.

The project adopted is to deepen the present or old channel by dredging to 9 feet at mean low-tide, with a width of 200 feet in the river and 150 feet in the bay between Ballast Point and Tampa.

The estimated cost of this work is $97,000.

Under an appropriation of $10,000, made by act of Congress approved June 14, 1880, proposals for dredging were invited, and on October 9, 1880, two bids were received (abstract of which is herewith attached), and the contract was awarded to Mr. Jas. E. Slaughter, the lowest bidder, at 50 cents per cubic yard.

Dredging operations were commenced on April 27, 1881, and continued until May 31, 1881, when work was suspended, the appropriation being exhausted; 1,853 cubic yards of material were removed, and a cut 2,900 feet long, 60 feet wide, and 9 feet deep at mean low-water, was ob-

tained, extending 1,300 feet south and 1,600 feet north of the "Barrel Stake."

By act of Congress approved March 3, 1881, an additional appropriation of $10,000 was made for this improvement, and the project of expending the same by continuing the dredging under the plan adopted having been approved, specifications were prepared and proposals for bids invited, to be opened at 12 m., July 9, 1881.

According to the original estimate the sum of $77,000 is required for the completion of the improvement, and this amount could be profitably expended during the fiscal year ending June 30, 1883, in continuing and possibly completing, the improvement.

The present state of the work does not enable one to make a full estimate as to its final cost, nor to form an opinion as to its permanency; the larger the appropriation the greater will be the competition between bidders, with a probable decrease in prices, and an early completion will assure its permanency, as the strong ebb current sweeping through the entire length of the dredged channel will prevent the accumulation of any considerable amount of sediment.

Until at least one cut 60 feet wide is completed throughout the entire length of the proposed channel, of which steamers can avail themselves, the commerce of this port can derive no benefit from the improvement.

Tampa not being a port of entry there is no record kept of the number or tonnage of vessels arriving there.

The value of the commerce to be benefited by this improvement s estimated to be fully $500,000. The principal article of export is cattle, of which about 15,000 are shipped to Cuba annually. With the increased facilities to navigation offered by the completion of the contemplated improvement, a proportionate increase in the commerce of the port may be reasonably expected.

This work is in the collection district of Cedar Keys, Fla., and Cedar Keys, is the nearest port of entry.

An appropriation of $77,000 is asked for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available,	$10,000 00	
Amount appropriated by act approved March 3, 1881,	10,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880,		9,885 61
July 1, 1881, amount available,		10,114 39
Amount (estimated) required for completion of existing project,		77,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		77,000 00

Abstract of bids received and opened October 9, 1881, relating to dredging in Tampa Bay, Florida.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	Jas. E. Slaughter	$0 50	June 1, 1881	One year.
2	S. N. Kimball	0 59	Sixty days	November 30, 1881.

K 9.

IMPROVEMENT OF SUWANNEE RIVER, FLORIDA.

The examination of this river was provided for by act of Congress approved June 18, 1878, and was made from its mouth to the bridge of the Jacksonville, Pensacola and Mobile Railroad, just below the mouth of the Withlacoochee River near Ellaville, Fla.

The plan adopted was to dredge a channel through the bars at East and West passes, at the mouth of the river, 5 feet deep at mean low-water and of sufficient width to accommodate the vessels employed in the commerce of that locality, to deepen the shoals and remove other obstructions in the river, so as to give a depth of 5 feet to Rolands Bluff, and from there to Ellaville, of 4 feet.

The amount (estimated) required to complete this project was		$55,158 00
The amounts appropriated are as follows:		
By act approved June 14, 1880	$5,000 00	
By act approved March 3, 1881	3,000 00	
		8,000 00
		42,158 00

It is proposed to expend this amount in dredging through the bar at East Pass, by contract, according to the adopted plan.

Under the first appropriation, advertisements for proposals for bids for dredging were published on September 9, 1880, and on October 9, 1880, three bids were received (abstract of bids hereunto attached). Mr. James E. Slaughter being the lowest responsible bidder, was awarded the contract, at 50 cents per cubic yard. Dredging should have commenced on this contract on January 1, 1881, but an extension of time having been granted the contractor, no work was done during the fiscal year.

Under the appropriation of March 3, 1881, advertisements for proposals of bids were published June 9, 1881, and will be opened July 9, 1881.

The amount, exclusive of former appropriations, required for the completion of this improvement contemplated, is $42,000. It is not thought the improvement will be permanent, and a small amount will be required yearly for its preservation; what amount, cannot yet be estimated. It is proposed to expend the amount asked for, for fiscal year ending June 30, 1883, in continuing the improvement according to the adopted plan.

The commerce to be benefited by this improvement consists in various farm products, cotton, sirup, &c., but principally in pine, cypress, and cedar timber, several millions of feet being shipped annually chiefly to Cedar Keys.

This work is situated in the collection district of Saint Mark's, and Cedar Keys is the nearest port of entry.

Amount of revenue collected at Cedar Keys for fiscal year ending June 30, 1881, $9,326.

Money statement.

July 1, 1880, amount available	$5,000 00	
Amount appropriated by act approved March 3, 1881	3,000 00	
		$8,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		314 26
July 1, 1881, amount available		7,685 74
Amount (estimated) required for completion of existing project		47 158 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		25,000 00

Abstract of bids received and opened October 9, 1881, relating to dredging at mouth of Suwannee River, Florida.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	S. N. Kimball	$0.59	Sixty days	One year.
2	James E. Slaughter	50	January 1, 1881	March 31, 1881.
3	William A. Alexander	55	Six months	Ten months.

K 10.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, ALABAMA AND FLORIDA.

The examination of this river from its mouth to Geneva was made in 1872, and the project adopted for its improvement was to remove all such obstructions as rendered the navigation of the river difficult and dangerous to Geneva, Ala.

During the year 1880 the examination of this river was extended to Newton, Ala., a distance of about 40 miles above Geneva, and the project adopted for the improvement of this section of the river is to make a channel for high-water navigation only, by the removal of snags, sunken logs, and overhanging trees.

The estimated cost of carrying out this project as far as Geneva is, as stated in my last year's report, $44,332. The estimated cost of carrying out the project from Geneva to Newton is $22,000. Total estimated cost is $66,332.

The following appropriations for this improvement have been made:

By act of Congress approved June 23, 1874	$5,000 00
By act of Congress approved March 3, 1875	5,000 00
By act of Congress approved August 14, 1876	5,000 00
By act of Congress approved March 3, 1879	5,000 00
By act of Congress approved June 14, 1880	7,000 00
By act of Congress approved March 3, 1881	10,000 00
Total appropriations	37,000 00
Total estimated cost	66,332 00
Total appropriations	37,000 00
Balance (estimated) required	29,332 00

The work accomplished under the appropriations for the improvement of this river, up to the end of the fiscal year ending June 30, 1881, is as follows:

The river was cleared of snags, stumps, overhanging and sunken trees, drifts, logs, brush, and willows for a distance of 140 miles; a number of sand and gravel bars were removed; a channel 30 feet wide, 3 feet deep, and 150 feet long was cut through a rock shoal about 1 mile above Cerro Gordo. The entire wrecks of the steamers Boston and Edward and half of that of the Eighth of January were removed.

The timbers and willows at a great number of points in the upper river were cut away, allowing the points to wash, thereby straightening the river. The river was made navigable for steamboats as far as Geneva during ordinary stages of water. The condition of the river on June 30, 1881, is such that steamers drawing 4 feet of water can ascend as far as Geneva with comparative safety.

Owing, however, to very short and sharp bends in the lower part of the river, and to the continual washing of banks, caused by the practice

of driving loose timber and logs, thus forcing trees to fall in almost daily, considerable care must yet be exercised in navigating that portion of the river.

The progress made in the work during the fiscal year ending June 30, 1881, is as follows: Four months' time was consumed in removing such obstructions to navigation as had accumulated in that portion of the river previously worked over. The entire wreck of the steamer Edward, near Bear Pen Bluff, and one-half of that of the Eighth of January, about 7 miles below Cerro Gordo, were removed.

A cut-off was opened through a narrow strip of land about 3 miles below Half-Moon Bluff; 1,377 snags, 151 stumps, 2,445 sunken trees, 10,283 overhanging trees, a large lot of willows, drift, and brush, and 252 cubic yards of sand and mud were removed.

The river for about 140 miles from the mouth up has not yet been thoroughly improved, as it offers a comparatively safe channel, with a depth of 4 feet at all stages of the river.

With one-half of the appropriation of $10,000, made by act of Congress approved March 3, 1881, it is proposed to remove, as far as the funds will permit, snags, stumps, and overhanging trees on that portion of the river between the mouth and Crawford Cut-off, a distance of about 40 miles, and with the remaining half to remove some rock bowlders from a shoal about 4 miles south of Geneva, and to remove snags and trees from the river from Geneva to Newton, for high-water navigation only, as far as the funds will allow.

The appropriation asked for for fiscal year ending June 30, 1883, it is proposed to apply to the removal of snags, stumps, and logs at Cypress Top Bar, at the mouth of the river, and of such snags, stumps, and trees as may have settled in that portion of the river already worked over; to the cutting away and removal of a great number of trees along the river liable to wash in, from the mouth up to Geneva, the present head of steamboat navigation; to the entire removal of the wreck of the steamer Eighth of January; to cutting a channel through a rock shoal about 4 miles south of Geneva, and to the completion of a channel for high-water navigation from Geneva to Newton.

The nature of the banks of this river will not admit of a permanent improvement, and it will require an annual expenditure of $2,000 to keep navigation open.

The commerce of that portion of Florida and Alabama through which the Choctawhatchee and its tributaries flow was, up to within the past year, confined principally to the cutting and shipping of saw-logs and timber, the annual shipment thereof being about 20,000,000 cubic feet. Since the improvement of the river commenced, and especially during the past fiscal year, the number of timber and log camps along the river and creeks have more than doubled, and it is estimated that from 50,000,000 to 60,000,000 of cubic feet were shipped down the river during last year.

Previous to the improvement the annual shipment of cotton down the river from Walton, Washington, and Holmes Counties, Florida, and Geneva County, Alabama, did not exceed 1,500 bales, from the fact that only very small steamers and light-draught barges could ply the river, and then only in high-water seasons.

During the past year, in consequence of the improvements made in the upper part of the river, four steamboats were placed on the line between Pensacola and Miller's Ferry, carrying cotton, guano, corn, oats, and general merchandise. Besides these steamboats there are em-

ployed on the river and Holmes Creek three schooners and five sloops, owned by parties living on the river and Holmes Creek.

During the past year there was carried down the river from Geneva and points on the river and Holmes Creek about 2,500 bales of cotton, 60 bales of wool, 1,000 barrels of sirup, 6,000 bushels of sweet-potatoes, and a large amount of country produce, and during the same period, up the river from Pensacola to Geneva and other points on the river and on Holmes Creek, 3,000 tons of guano, about 12,000 bushels of corn and oats, and a large amount of provisions, dry goods, farming implements, &c.

The following table shows the increase in commerce during fiscal year ending June 30, 1881:

Down the river:

	1880.	1881.
Timber, &c	$1,500,000 00	$3,000,000 00
Cotton	75,000 00	125,000 00
Wool	2,000 00	7,000 00
Sirup	3,000 00	12,000 00
Potatoes	1,000 00	3,000 00
Miscellaneous	5,000 00	10,000 00
	1,586,000 00	3,157,000 00

Up the river:

	1880.
Corn, oats, salt, &c	$4,500 00
Provisions, &c	100,000 00
Miscellaneous	50,000 00
	154,500 00

	1881.
Guano	$150,000 00
Corn, oats, &c	12,000 00
Provisions, &c	150,000 00
Miscellaneous	125,000 00
	437,000 00

The large increase in the yield of cotton by the use of guano will induce planters to use it more freely, and will bring into cultivation the pine-woods land heretofore considered worthless, and it is expected that the demand for this fertilizer during next fall will exceed 7,000 tons.

The increased commerce in timber, lumber, and saw-logs will also demand a corresponding increase in the supply of corn, oats, provisions, &c.

It is estimated by merchants and planters that in Washington, Holmes, and Geneva counties about 15,000 bales of cotton will be made this fall, most of which will be shipped down the river.

The shipments of sirup, wool, and country produce will be largely increased, owing to better and safer facilities in transportation.

The commerce in the country along the Upper Choctawhatchee River, from Geneva to Newton, and above Newton, consists principally of cotton, corn, oats, and fruit, very little being done in the timber business. About 8,000 bales of cotton are annually shipped from Newton, and these, as well as necessary plantation supplies, have to be hauled to and from Chattahoochee, Eufaula, or Troy, a distance of from 50 to 70 miles.

No work having been done on the improvement of the river above Geneva, no increase in trade has taken place, but it is estimated that by improving the river for high-water navigation to Newton, Newton will be the shipping point for a radius of country of from 40 to 50 miles, and that from 25,000 to 30,000 bales of cotton will be shipped from that county annually.

The supply of corn, provisions, guano, and plantation supplies, &c., will be proportionate to the number of bales of cotton raised. As a consequence of the improvement made during the last six years, and particularly so during the last working season, three steamboats and a barge were put in the trade between Pensacola and Geneva, and a steam launch, a large barge, several schooners, sloops, and flats in the Holmes Valley trade.

Since the improvement of this river began, and more so during the last year of the work, there has been a marked increase in the commerce carried on between points on this river and Holmes Creek and Pensacola; in fact, it may be safely said that the commerce has increased tenfold in the last five years.

This work is situated in the collection district of Pensacola, Fla., and Pensacola is the nearest port of entry.

Money statement.

July 1, 1880, amount available	$8,047 53	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$18,047 53
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		8,414 86
July 1, 1881, amount available		9,632 67
Amount (estimated) required for completion of existing project		86,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		25,000 00

STATEMENT OF NATURE AND VALUE OF EXPORTS FROM PENSACOLA, FLA., DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

	Value.
4,232,205 cubic feet hewn timber	$550,316
6,200,174 cubic feet sawed timber	806,022
77,119,000 feet, B. M., lumber	1,079,666
9,421 bales cotton	376,840
Total exports	2,812,844

509 vessels cleared, with a tonnage of 303,910 tons.

The amount of revenue collected at this port can only be given from December 1, 1880, to June 30, 1881 (the records prior to former date having been destroyed by fire); said amount is $80,732.44 for the seven months.

K 11.

IMPROVEMENT OF WITHLACOOCHEE RIVER, FLORIDA.

An examination of this river, authorized by act of Congress approved March 3, 1879, was made from Haye's Ferry to its mouth, during September, 1879, and the report submitted March 6, 1880, is contained in annual report of the Chief of Engineers for 1880.

The project adopted is to improve the river by the removal of snags, overhanging trees, and loose rocks, and the deepening of some of the worst shoals and a bar near the mouth of the river, so as to enable boats drawing 2 feet of water to navigate the river during about half of the year. The present depth of the river varies from 1 to 7½ feet, with a width of from 50 to 160 feet, and the cost of the improvement is estimated at $23,900.

An appropriation of $7,500 was made for this work, by act of Congress approved March 3, 1881, and it is proposed to expend this amount in prosecution of work on this improvement according to approved project, during the year ending June 30, 1882.

With the appropriation of $16,400, asked for fiscal year ending June 30, 1883, it is proposed to complete the improvement, which will not be

permanent; the amount required to preserve the work cannot yet be estimated; but will be small. The trade consists principally in oranges.

This work is in the collection district of Key West, Fla. Key West, Fla., is the nearest port of entry.

Money statement.

Amount appropriated by act approved March 3, 1881	$7,500 00
July 1, 1881, amount available	7,500 00
Amount (estimated) required for completion of existing project	16,400 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	16,400 00

K 12.

IMPROVEMENT OF PEAS CREEK, FLORIDA.

The examination of this creek was provided for by act of Congress approved March 3, 1879, and was made, from its mouth to Fort Meade, during October and November, 1879, and the report submitted March 10, 1880, is contained in annual report of the Chief of Engineers for that year.

The project adopted is to improve the creek for high-water navigation, by the removal of snags, sunken logs, overhanging trees, and loose rocks from the channel, from its mouth to Fort Meade.

The present depth varies from 6 inches to 8 feet, with a width of from 50 to 150 feet.

The entire cost of the improvement is estimated at $16,700.

An appropriation of $7,000 was made for this work, by act of Congress approved March 3, 1881, and it is proposed to expend this amount in prosecution of work on this improvement, according to the approved project, during the fiscal year ending June 30, 1882.

With the appropriation of $9,700, asked for year ending June 30, 1883, it is proposed to complete the improvement, which will not be permanent. The amount required to preserve the work cannot yet be estimated, but will be small.

The principal trade is carried on between Cuba and Cedar Keys, and consists in export of cattle to the former and oranges to the latter place, but I have not been able to obtain any reliable statistical statement.

This work is in the collection district of Key West, Fla. Key West is the nearest port of entry.

Money statement.

Amount appropriated by act approved March 3, 1881	$7,000 00
July 1, 1881, amount available	7,000 00
Amount (estimated) required for completion of existing project	9,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	9,700 00

K 13.

IMPROVEMENT OF ESCAMBIA RIVER, FLORIDA AND ALABAMA.

An examination and partial survey of this river was made under authority of act of Congress approved June 18, 1878, from the Alabama and Florida State line to its mouth, and report on same is contained in annual report of Chief of Engineers for 1879.

The plan adopted for this improvement was to dredge a channel

through the bar at the mouth of the river 150 feet wide and 5½ feet deep at mean low-water, remove snags and overhanging trees the whole length of the river, and to construct a few dams and jetties where the channel is divided or much widened, and shore protections where the banks show an inclination to wash and cave.

The least depth at present over the bar is 1.9 feet; the river proper affords a sufficient depth of water, and only needs the above-mentioned improvements.

The first appropriation for this work, $8,000, was made by act of Congress approved June 14, 1880; this amount it was proposed to expend in dredging by contract, and under date of September 9, 1880, advertisements for proposals for bids were published. On October 9, 1880, bids were received and opened (abstract of same hereunto attached), and by letter of Chief of Engineers, dated October 18, the contract was awarded to Mr. William A. Alexander at 47½ cents per cubic yard, he being the lowest bidder. Under this contract, work was to have commenced on May 24, 1881, but on account of unforeseen delays an extension of time was granted the contractor until August 24, 1881, time of completing contract remaining the same; consequently no work was done during this fiscal year.

By act of Congress approved March 3, 1881, an appropriation of $5,000 was made for this improvement, and it is proposed to apply $1,500 to the completion of the dredged channel through the bar, and the remaining $3,500 to the construction of submerged dams at the heads of East and Gum rivers and dike across the mouth of McVoy's Pass to deflect and conserve the water to the channel of the main river.

Advertisements for proposals for bids for dredging were published June 9, 1881, and will be opened July 9. All other work will be carried on by hired labor and purchase of materials in open market. This improvement, when completed, will not be permanent in its character, but will require a comparatively small amount every two or three years for its preservation.

The appropriation asked for for fiscal year ending June 30, 1883, it is proposed to apply to the completion of the project adopted, by the removal of obstructions from the river and the construction of jetties and shore protections where necessary. No work having been done, the commerce on this river, which consists mainly in timber and lumber, about 5,000,000 feet yearly, has not yet received any benefit from the improvement.

Amount estimated required for this work	$25,000 00
Total amount appropriated	13,000 00
Amount required for completion of improvement	12,000 00

This amount, $12,000, could be profitably expended during fiscal year ending June 30, 1883.

This work is situated in the collection district of Pensacola, Fla., and Pensacola is the nearest port of entry.

Money statement.

July 1, 1880, amount available	$8,000 00	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$13,000 00
July 1, 1880, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		328 69
July 1, 1881, amount available		12,671,31
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		12,000 00

Abstract of bids received and opened October 9, 1881, relating to dredging at mouth of Escambia River, Florida and Alabama.

No.	Name of bidders.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	S. N. Kimball	$0 50	Sixty days	One year.
2	James E. Slaughter	55	May 1, 1881	December 1, 1881.
3	William A. Alexander	47½	Six months	One year.

K 14.

IMPROVEMENT OF ALABAMA RIVER, ALABAMA.

The examination and partial survey of this river was made during the months of July to October, 1875, as provided by act of Congress approved March 3, 1875.

The report was made in March, 1876, and is contained in the Annual Report of the Chief of Engineers for 1876.

The project adopted was designed to obtain a channel depth of 4 feet at low-water, with a minimum width of 200 feet, from the mouth of the river, 50 miles above Mobile, Ala., to Wetumpka, Ala.

The estimated cost was $229,741.

The appropriations made for the work are as follows:

Act of Congress approved June 18, 1878	$25,000 00
Act of Congress approved March 3, 1879	30,000 00
Act of Congress approved June 14, 1880	25,000 00
Act of Congress approved March 3, 1881	20,000 00
Total	100,000 00

Work was commenced on the improvement at low-water season of 1878, and prosecuted through the fiscal years ending June 30, 1879, June 30, 1880, and continued during the fiscal year ending June 30, 1881.

During the previous fiscal year the right-hand chute at Yellow Jacket Bar was partially closed by a rock dam 400 feet in length. The work was left in an unfinished state owing to the high stage of water in the river, and no work was undertaken there during the present fiscal year.

The dam across the left-hand chute at Gardner's Island was nearly completed at the close of the last fiscal year, but the work was seriously interrupted by a rise in the river during the month of July of the present year.

The chute was, however, closed with great difficulty during the month of August, and the force moved from that point to Cox's Bar, 15 miles below Montgomery; where work was commenced in collecting the material for and constructing a dam, closing the right-hand chute at this point.

Operations were seriously retarded by a rise in the river, and were finally suspended in the month of September and the force moved to Hadnot's Bar, 2 miles further down.

By the time material could be prepared for the contemplated improvement at this point the river had receded sufficiently to resume operations at Cox's Bar; but there again occurred another rise of 8 feet, when the force was moved up to Three Chutes, 1½ miles below Montgomery. The work of closing the right-hand chute at Three Chutes Bar was successfully completed during the latter part of the month of September. During a portion of the month of October work was prosecuted, completing the works at Cox's and Hadnot's bars, and removing snags and logs from the bed of the river at Monack's and Gardner's islands. The work of closing the Cut-Off, 25 miles above the mouth of the river, by a brush

and stone dam was completed during the fiscal year ending June 30, 1880, and the work remained in good condition until the month of October, 1880, when a break occurred between the jetty and upper or north end of dam. This break was found on examination to be about 100 feet in width, with an average depth of about 15 feet, and was caused by a heavy drift lodging against the head of the guide piling. As soon as possible after the break was reported the steam snag-boat, with barges, proceeded to the Cut-Off, and steps were immediately taken to collect material for repairing the damage. On account of the deep and swift water in the break the location of the protection dam was made above the break where the water was from 5 to 9 feet in depth with much less current, rendering the putting in of the new work much less hazardous. The new dam was so located as to surround the breach on the upper side, starting from the main dam and connecting with the jetty below, and consisted of two rows of cribs set to guide piles, the upper row of cribs being 3 feet higher than the lower, and all filled with stiff clay, the best and only material to be obtained near at hand that proved capable of resisting the erosive action of the water. This and the shore protection of the old work at the Cut-Off was prosecuted successfully through the month of November, engaging the services of the entire force on the river until a suspension of operations was rendered necessary by a permanent rise in the river December 7, 1880.

On the 18th of May, 1881, after a thorough repair of the boats, the river having receded to near the summer stage, the steam snag-boat and jetty boats, with labor force and outfit, left Mobile for the cut-off, to resume work at that point. An examination was made as to the condition of the work, which seemed to be intact and serving its purpose well, but, owing to the high stage of water in the river, above low-water some 4 feet, no thorough examination was practicable. The force was therefore moved up the river to the vicinity of Claiborne, and were engaged in procuring stone ballast and placing it on the banks adjacent to the works at the cut-off, preparatory to placing it in position. The river having fallen sufficiently during the latter part of the year, 35 piles were driven along the front of the cribs placed during the fall and 11 cribs filled with rock sunk. These cribs were 7 feet in height, and after being filled with rock and faced with stiff clay, to prevent scour along their front, closed the breach.

A marked increase in the depth of water in the channel has been noticed, and it is possible that still further changes will take place, affording the desired depth, which here is 6 feet for low-water navigation.

The following table shows the amount and character of the work accomplished during the present fiscal year.

Names of places.	Miles from Mobile.	Rock dams.	Cribs laid.	Stone used in dams.	Gravel used in dams.	Stone used in dams.	Clay used in dams.	Fascines made.
		Lin. ft.	*Lin. ft.*	*Cu. yds.*	*Cu. yds.*	*Tons.*	*Cu. yds.*	*No.*
Gardner's Island	320	.....	.....	550	1,800	.....	.....	1,800
Cox's Bar	376	690	.....	.....	800	230	.....	658
Hadnot's Bar	374	600	.....	.....	.....	.....	.....	.....
Cut-off	70	.....	230	.....	.....	896	780	.....
Three Chutes	385	350	.....	.....	.....	.....	.....	.....
Bar in river below Cut-off	70	.....	.....	.....	.....	.....	.....	.....

Names of places.	Mattresses laid.	Mattresses laid.	Shore end of dam built.	Piles driven.	Original depth.	Present depth.	Logs and snags removed.
	Cu.yds.	*No.*	*Feet.*	*No.*	*Ft. In.*	*Ft. In.*	*No.*
Gardner's Island	1,460	31	200	600	2 00	3 5	366
Cox's Bar	.....	.....	.....	616	2 5	4 00	274
Hadnot's Bar	.....	.....	.....	.....	2 00	3 5	416
Cut-off	.....	.....	.....	137	14 00	Closed.	1
Three Chutes	.....	.....	.....	.....	2 00	4 00	152
Bar in river below Cut-off	.....	.....	.....	.....	2 5	5 00	.....

It is proposed to use the amount available at the close of the last fiscal year ($21,854.20), together with the amount appropriated by act of Congress approved March 3, 1881 ($20,000), in the following manner:

1. To complete the dam now being constructed for the protection of the works at the "Cut-off," and to build necessary jetties below the present improvements so as to increase the depth of water over the bar at that point. To complete the improvements at Yellow Jacket Bar, and to make necessary additions and alterations to the improvements at Gardner's Island as will afford a better channel than already exists.

2. To improve such bars on the upper portion of the river below Montgomery as surveys or information from steamboatmen may indicate as being most dangerous or troublesome to navigation.

3. To continue removing snags, sunken logs, and other obstructions from the channel of the river, and to remove such overhanging and leaning trees as are in the way, or are liable to fall into the river.

4. To build a light draught steam snag-boat for general service in connection with the improvement.

5. To survey as many bars, taking them in the order of their importance, as the stage of water will admit of, as only an inconsiderable number of the bars reported in the survey of 1876 were surveyed and mapped.

It is proposed to expend the appropriation asked for for the fiscal year ending June 30, 1883, in continuing and perfecting the work of improvement according to the project recommended in the annual report of 1876.

The amount required for continuing and completing the work as designed, exclusive of former appropriations ($100,000) is estimated at $130,000. Of this amount, $50,000 can be profitably expended during the fiscal year ending June 30, 1883.

The work, when completed, will not be permanent in its character, but will require an annual expenditure of about $10,000 to remove such snags and logs as will lodge in the bed of the river; to improve with new works such bars as are liable to form after every freshet, as well as to preserve and add to the works of improvement already completed and those contemplated.

As the steam snag-boat now in use will soon be unserviceable, and as the improvements contemplated demand the services of a first-class steam snag-boat, in order that this important water-way may be properly kept open for navigation during the entire year, it is respectfully recommended that a suitable boat be provided at as early a day as possible. Since the improvement of the river began, and owing to its partially improved condition, the commerce of the river has steadily increased, notwithstanding the competing facilities afforded for transportation by rail over the line of road between Montgomery and Mobile.

The results obtained by the work done are:

1. Increased safety to navigation, the boats plying on the river being able to run at nights and in foggy weather, when they were formerly obliged to tie up to the bank.

2. Greater regularity with less time consumed in making trips during low-water, and the carrying of larger loads than formerly, owing to the increased depth of water over the bars.

3. Uninterrupted communication during the entire season on that portion of the river between the cut-off and the mouth of the river, consequent upon the works of improvement completed at that point.

The number of bales of cotton shipped down the river during the past fiscal year to Mobile was 46,244, at an average value of $50 per bale, amounts to	$2,312,200 00
The up freights, consisting of bagging, ties, agricultural implements, corn, bacon, and an innumerable variety of plantation supplies, is estimated at about 80 per cent. of the value of the shipments of cotton brought down, say	1,849,760 00
To this should be added a large and increasing business done on the upper portion of the river between Selma and Wetumpka and intermediate points.	
It is estimated that at least 18,000 bales of cotton are hauled and moved on this portion of the river, together with large shipments of cotton seed, corn, and various plantation supplies, the value of which will be about as follows:	
18,000 bales of cotton at an average value of $50 per bale	900,000 00
Other freights, say 50 per cent. of the value of cotton	450,000 00
Total	5,511,960 00

It is expected that there will also be a large business done in transporting coal from the Warrior and Cahaba coal fields from points on the upper part of the rivers to Mobile. The success of this enterprise will, however, depend upon the uninterrupted and unobstructed navigation of the river, which it is the object of this improvement to accomplish.

The work is situated in the collection district of Mobile, and Mobile is the neares port of entry.

The amount of revenue collected at Mobile during the past fiscal year was $258,182.10.

An appropriation of $50,000 is asked for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$40,542 24	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$60,542 24
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		18,688 04
July 1, 1881, amount available		41,854 20
Amount (estimated) required for completion of existing project		129,741 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

K 15.

IMPROVEMENT OF WARRIOR AND TOMBIGBEE RIVERS, ALABAMA AND MISSISSIPPI.

I. BLACK WARRIOR RIVER.

The survey of this river was made, in compliance with the provisions of the river and harbor act of June 23, 1874, from its mouth to Locust Fork, from August to November, 1874.

The report upon it was submitted January 27, 1875, and forms a part of the Annual Report of the Chief of Engineers for that year.

The project adopted was to so improve the river as to give a channel 80 feet wide and 4 feet deep at low-water, from the mouth up to Tuskalóosa, Alabama, by the removal of snags, overhanging trees, and deepening bars by the construction of dams, wing-dams, dredging, and blasting; the estimated cost of which was $151,103.

The following appropriations have been made for this improvement:

By act of March 3, 1875, for the Black Warrior below Tuskaloosa, and the Tombigbee below Demopolis	$25,000 00
By act of August 14, 1876, for the improvements of the Warrior and Tombigbee rivers	15,000 00
By act of June 18, 1878	40,000 00
$28,000 on the Warrior and Tombigbee, and $12,000 on the Tombigbee above Columbus.	
By act of March 3, 1879	30,000 00
of which sum $10,000 shall be expended on the Tombigbee above Columbus, and $20,000 on the Warrior River and Tombigbee below Columbus.	
By act of June 14, 1880	47,000 00
of which $20,000 shall be expended on the Warrior, $12.000 on the Tombigbee between Columbus and Vienna, and $15,000 on the Tombigbee below Vienna.	
By act of March 3, 1881	25,000 00
To be expended in the same proportion as the appropriation of June 14, 1880.	

Work was commenced on this improvement in July, 1875, under the appropriation of $25,000 made by act of Congress approved March 3, 1875, at Tuskaloosa, Ala., and continued down stream during the low-water seasons of 1876–1877, and for two months in 1878, when the force and equipment were placed upon the Tombigbee.

No further work was done on this river until October last, when work was commenced under the allotment of $20,000 from the appropriation of June 14, 1880, at McIntyre's Shoals, 25 miles above Demopolis. Up to June 30, 1881, twenty-five months have been spent on the work, since the commencement. The following work was done during the fiscal year ending June 30, 1881.

Number of bars worked upon	2
Number of logs removed	96
Number of trees cut	490
Linear feet of dams and jetties	851

The bars improved lie between Tuskaloosa and Hickman's, 75 miles below. The effect of the work done has been to increase the low-water depth from 14″ (at Log Shoals, 70 miles below Tuskaloosa) to a minimum of 30″, which exists on 8 or 10 of the upper bars, with probably not over 2 feet at Tressel's Bar (30 miles below Tuskaloosa), where the dam was partially injured by a steamboat and the water diverted from the channel.

The other bars generally afford 2½ to 4 feet. Navigation has been much facilitated by the removal of logs and leaning timbers along the whole length of the river.

The improvements made seem in general to be permanent, though the slides and lodgments of drift logs, which occur to some extent every year, will render some annual repairs necessary. As just indicated, some of the first year's work needs revision and additions, which will be made during the present season.

As soon as the allotment of $20,000 became available a log-boat and barge were contracted for in Mobile, which were completed October 12, and towed up to the mouth of the Warrior. There they were joined by a quarter boat from the Tombigbee, and the force commenced work Octo-

ber 21, at McIntyre's Shoals. This shoal was the most serious obstacle in the lower portion of the river, being more than half a mile in length, and affording only 19 inches at low-water.

The river immediately commenced swelling, and after building 972 feet of rock and brush dams, and partially removing the wreck of a steamboat, sunk 30 years ago, work was suspended November 20. In the mean time an extraordinary local freshet had occurred between Eutaw and Steele's Bluff, flooding several creeks, while the river was low, the effect being to deposit in the river, at the mouths of Buck's, Sim's. and Minter's Creeks, large piles of trees and drift that choked up the channel and cut off low-water navigation. The log-boat was sent up the river to clear the channel, but by the time it had reached Steele's Bluff, at the mouth of Buck's Creek, 60 miles below Tuskaloosa, the river had risen 35 feet, and the boat was laid up. It being impossible to clear the channel before low-water, the log-boat resumed work in February, continuing with two interruptions from freshets. The deposits from the three creeks, a slide below Finch's Ferry, and an accumulation of drift at the unfinished railroad bridge, 5 miles from Eutaw, were removed. The log-boat then moved down stream cutting leaning timber and removing logs, until reaching McIntyre's Shoals, May 25, when a jetty force was organized and work resumed; the jetties on this and Laster's Bar, 1 mile above, were completed before the close of the year.

It is proposed to apply the funds available for expenditures during the fiscal year ending June 30, 1882, to building a quarter boat and barge at Tuskaloosa, and proceed down the river, making such additions and repairs to the work formerly done as may be found necessary.

The force at McIntyre's will work the river, removing logs and improving all bars that do not afford a depth of 3 feet at low-water. With a favorable season it is expected that a 3-foot channel, 50 feet in width, and free from logs, will be secured throughout.

The funds asked for for fiscal year ending June 30, 1883, it is proposed to use in completing the work as far as possible according to the original plan, which was to secure a channel 80 feet wide and 4 feet deep at low-water.

The amount exclusive of former appropriations required for the entire completion of the work is estimated at $75,000. In addition to this amount, and subsequent to its expenditure, there will be required an annual outlay of $3,000, mainly to remove logs and slides that lodge in the channel during the winter floods. This is on the supposition that a steam snag-boat would be employed for this service on the Warrior and Tombigbee rivers jointly.

The benefits to commerce from the improvements already made are very marked, not so much in the increase of business done, as in the reduction of transportation charges. Previous to 1877 boats were rarely able to ascend the Warrior between August and December 15. During these months about 15,000 bales of cotton were shipped by rail, at a charge of $2.50 per bale; return freights were correspondingly high, $12 per cask having been charged for bacon. In consequence of the partial improvements made, light draught boats have since 1877 run the river from September, causing a reduction in charges on cotton to $1 per bale, and on bacon to $3 per cask, with a similar reduction on groceries, bagging, ties, &c. Hence the annual saving to the community for the past four years has not been less than $25,000 to $30,000. It is safe to say that the money spent upon the Warrior has been already more than reimbursed in the saving in transportation charges.

Finding that summer navigation is now practicable for small boats,

the Dubois Manufacturing Company of Tuskaloosa propose to build a boat this summer for the accommodation of the business, and the local trade generally.

It is thought that considerable business will be developed from the transportation facilities afforded to the river plantations for 75 miles below Tuscaloosa.

Since September 1, 16,000 bales of cotton have been taken out of the Warrior River and about 3,000 tons of miscellaneous freights delivered at the various landings. During the year ending September 1, 1880, 15,479 bales of cotton were shipped from the Warrior River to Mobile. Comparisons with former years cannot be made, as previous to last year the practice was to credit the Warrior with the cotton brought by the Warrior boats to Mobile, though much of it was taken from landings on the Tombigbee below Demopolis.

The future traffic on the Warrior when the proposed improvements shall have been completed will consist largely of the transportation of coal from Tuscaloosa. The estimated cost by the river in barges is 50 cents per ton to Mobile, while by rail, the only means of transit, the charge is not less than $2.25 per ton. Coal mining in the Warrior coal fields is rapidly increasing, the output having risen from 200,000 tons in 1879 to 340,000 tons in 1880.

As soon as the river can be made available as an outlet it will be extensively utilized for coal transportation, and the reviving industry will be greatly stimulated.

This work is situated in the collection district of Mobile, Ala., and Mobile is the nearest port of entry.

Revenue collected for fiscal year ending June 30, 1881, $258,182.10.

II. TOMBIGBEE RIVER BETWEEN COLUMBUS AND VIENNA.

The present project for the improvement of this section of the river was adopted in 1872 and modified in 1879. The object is to afford a low-water channel of navigable width, with a depth of 3 feet from Columbus to Vienna.

Under the act of Congress approved March 3, 1879, appropriating $20,000 to the improvement of the Warrior and Tombigbee rivers below Columbus, a force was organized and put to work October 26, 1879, at Curtis Island, one-half mile below Columbus. The work was suspended November 23 by high-water, partial improvements having been made down to the head of Ten-Mile Shoal, 13 miles below Columbus. In the following May this force resumed work above Ten-Mile Shoals, removing logs and felling overhanging trees 2 miles down the shoals, and then, passing down to Union Bluff, continued this work to Coal-Fire Creek, 10 miles below.

During September this equipment was laid up on account of high-water, and in October was transferred to the Warrior River. On the 1st of May, 1880, a log-boat and barge were taken in tow at Mobile, and on the 11th reached the foot of Ten-Mile Shoals, commencing work next day.

These shoals have always been a serious obstacle to navigation, being so badly choked with logs that a passage was seldom attempted on less than a 5 or 6-foot stage of water. They were also obstructed by 11 bars that afforded from 16 to 20 inches only at low-water.

The work attempted was to deepen the bars to 3 feet, and to remove the logs. The latter object was mainly accomplished, and, 7 bars were

improved by the 1st of September. At that time the river rose 17 feet and did not again recede sufficiently to continue work on the shoals.

The force was moved to Curtis Island, finishing the improvement at that point, and on the 6th of November, the river continuing high, work was suspended. After July 1, the work was done under the act of June 14, 1880, appropriation $12,000 to the Tombigbee from Columbus to Vienna. On the 15th of April the log-boat commenced dragging the crest of the bar at the head of the shoals, to dislodge the embedded logs and drift, and allow the sand to scour out. The same thing was done at Harrison's Chute, Butler's Island, and Gaston's Shoals with good effect, the full stage of water at that time affording a strong current. This work is being supplemented with wing-dams, in order to retain and, when necessary, increase the depth gained. The force was increased on the 23d of May, the river having nearly reached low-water, and jetties were commenced at Gaston's Shoals, the log-boat at the same time commencing work on the Rock Shoals, 3 miles below Columbus.

The following table shows the work done:

Name of bar.	Distance below Columbus.	Depth before improved.	After improved.		Brush dams,	Bank protection.	Logs removed.	Trees felled.	Remarks.
			Depth.	Width.					
	Miles.	*Inches.*	*Feet.*	*Feet.*	*Lin. ft.*	*Lin. ft.*	*Number*	*Number*	
Ten-Mile Shoals, No. 1..	20	22	3	40	.....	.....	.....	.....	
Ten-Mile Shoals, No. 2..	19½	22	3	40	.....	.....	.....	.....	
Ten-Mile Shoals, No. 3..	19	16	3	35	.....	.....	.....	.....	
Ten-Mile Shoals, No. 4..	18½	22	3	35	.....	.....	.....	.....	Wild Cat Bar.
Ten-Mile Shoals, No. 5..	17	16	3	40	.....	.....	.....	.....	
Ten-Mile Shoals, No. 6..	16½	14	3	35	.....	.....	.....	.....	
Ten-Mile Shoals, No. 7..	15½	14	3	35	.....	.....	.....	.....	
Ten-Mile Shoals, No. 8..	15	16	*	.....	.....	.....	.....	.....	Moore's Bluff.
Ten-Mile Shoals, No. 9..	14	16	*	....	.....	.....	.....	.....	
Ten-Mile Shoals, No. 10.	13½	16	*	.....	.....	.....	.....	.....	
Ten-Mile Shoals, No. 11.	13	16	*	.....	.....	.....	.....	.....	Head of Ten-Mile Shoals.
Harrison's Chute	9	24	*	.....	.....	.....	.....	.....	
Butler's Island	6	16	*	.....	.....	.....	.....	.....	
Gaston Shoals	3½	16	*	.....	.....	.....	.....	.....	
Rock Shoals	3	14	*	.....	.....	.....	.....	.....	
Curtis Island	½	8	3	30	.....	.....	.....	.....	
Totals	.....	.....	.....	.....	5,656	1,541	1,407	1,075	

* Unfinished.

By act of Congress approved March 3, 1881, $6,383 was assigned to this improvement for fiscal year ending June 30, 1882.

It is proposed to apply these funds, with balance on hand, to remove the most troublesome log obstructions between Vienna and Ten Mile Shoals, and to improving all bars that afford less than 2 feet at low-water. It is proposed to apply the funds asked for, for fiscal year ending June 30, 1883, to completing the improvement as far as possible, giving a 3-foot low-water channel, of 35 feet minimum width, free from logs and other obstructions.

The amount, exclusive of former appropriations, required for the entire completion of this work, is $23,000, of which $14,000 can be expended during the fiscal year ending June 30, 1883.

To maintain the efficiency of the improvement will require an annual outlay of $2,000 should this service be performed for both the Tombigbee and Warrior rivers by the same boat.

The nature and extent of the commerce to be benefited by this im-

provement has been mainly included in my report on the Tombigbee below Vienna. Aside from this commerce there is a local business of considerable importance, that has been benefited by the work alrea dy done. Owing to the partial improvement of Ten Mile Shoals, boats can ascend to Columbus with 3 feet less water in the river than formerly. Encouraged by this fact, a small boat was built to ply between Columbus and Miller's Landing, a point where the Alabama and Great Southern Railroad touches the Tombigbee 2 miles above the bridge at Jones' Bluff, the object being to secure a northern rail connection that would compete with the Mississippi and Ohio Railroad. The effect was to reduce the through rates on compressed cotton (of which Columbus shipped 20,000 bales during last season) $2 per bale, and the reduction on return freight was such that the merchants of Columbus compute their annual savings in freight bills at from $300 to $500 each.

The owners of the boat state that the business done by their boat for four and a half months was—

8,000 bales of cotton to Miller's from Columbus.
124 bales of cotton to Miller's from way landings.
804 bales of cotton from way landings to Columbus.
3,032 sacks cotton seed from way landings to Columbus.
250,000 pounds meat from Miller's to Columbus.

In addition there were also carried to and from Miller's and way landings, and Columbus, large quantities of corn, oats, provisions, and general merchandise. It is difficult to obtain a correct estimate of these items. There is no doubt that with further improvements in the river there will be a continual increase of business to and from this place.

The president of the Board of Trade of Columbus estimates the probable receipts of cotton at Columbus for the year ending September 1, 1881, will be 27,000 bales, and next year's receipts 40,000 bales, basing these estimates upon the fact that Columbus has become a better market, in consequence of reduced transportation charges, caused by the improvement of the river.

This improvement is in the collection district of Mobile, Ala., and Mobile is the nearest port of entry.

The revenue collected during fiscal year ending June 30, 1881, was $258,182.10.

III. TOMBIGBEE RIVER, BELOW VIENNA.

The present project for the improvement of this section of the river was adopted in 1871, and modified in 1879. The object is to afford a low-water channel of navigable width, and 4 feet in depth, from its mouth to Demopolis, and 3 feet from Demopolis to Vienna.

The following are the various appropriations applicable to this improvement:

By act of March 3, 1875, for the Warrior, below Tuskaloosa, and Tombigbee, below Demopolis, $25,000.

By act of August 14, 1876, for the improvement of the Warrior and Tombigbee, $15,000.

By act June 18, 1878, $40,000; on the Warrior and Tombigbee, $28,000, and $12,000 on Tombigbee above Columbus.

By act March 3, 1879, $30,000; of which, $10,000 shall be expended on the Tombigbee above Columbus, and $20,000 on the Warrior and Tombigbee below Columbus.

By act June 14, 1880, $47,000; of which, $20,000 shall be expended on the Warrior, $12,000 on the Tombigbee between Columbus and Vienna, and $15,000 on Tombigbee below Vienna.

By act of March 3, 1881, $25,000 to be allotted in the same proportion as indicated in act of June 14, 1880.

Under the above appropriations, work was confined to the Warrior River until September 10, 1878.

The equipment was then transferred to the Tombigbee below Demopolis, and during the remainder of the fiscal year improvements were effected at Turkey Shoals, Barney's, Sellar's, Osage, and Hatcheetigbee, covering a distance of 71 miles and including the most troublesome bars between Mobile and Demopolis.

The most dangerous snags and logs were also removed between Demopolis and Jackson, a distance of 133 miles.

The next fiscal year, ending June 30, 1879, found the working party at Peavy's, 3 miles below Hatcheetigbee, but complaints having been made that a disproportionate amount of the appropriation was being expended below Demopolis, a steamer was chartered, and the jetty force moved to the mouth of the Warrior, 1 mile above Demopolis, which point was reached July 19.

The log-boat remained below a month longer to remove the logs for 5 miles below Jackson which were troublesome and dangerous. The work was carried on above Demopolis, until closed by high-water November 23, covering a distance of 20 miles, and including 10 bars.

The amount allotted to this section of the river, $15,000, from the appropriation of June 14, 1880, did not become available until the middle of August. As upon resuming work in the spring of 1880, the equipment had all been sent above Vienna, it became necessary to provide a new outfit for the section below. By the last of August, before arrangements for building boats could be made, the river rose, and it was thought advisable to await further appropriation, in the belief that it would be sufficient to justify the building of a suitable snag-boat which the work greatly needs. Under the appropriation of March 3, 1881, an allotment of $7,979 was made to this improvement, making, with former ones, the sum of $22,797. This amount being insufficient to build such a boat as was desired, and maintain her throughout the year with an effective force, authority has been asked to buy a steamboat at a cost not exceeding $5,000 (a convenient boat that will be serviceable for several years being procurable for that sum) and to build a log-boat and barge.

The following shows the work done on this improvement:

Name of bar.	Distance from Mobile.	Brush and stone dams.	Logs removed.	Trees cut.	Original depth.	Present depth.	Remarks.
	Miles.	*Lin. ft.*	*No.*	*No.*	*Ft. In.*	*Ft. In.*	
Peavy's	130	275	.....	.....	2 6	2 6	Unfinished brush and gravel dams.
Hatcheetigbee	134	653	.....	.....	2 6	3 6	Do.
Osage	152	895	.....	.....	2	4	Do.
Sellar's	153	935	.....	.....	2	3 3	Do.
Barney's	169	175	.....	.....	2 3	4 6	Do.
Turkey Shoals	205	850	.....	.....	1 8	3 3	Do.
Mouth of Warrior	244	305	.....	.....	1 10	3	Do.
Hancock's	246	520	.....	.....	1 10	3	Do.
The Rocks	246½	541	.....	.....	1 6	3	Do.
Bee Tree Island	247	322	.....	.....	2	3	Stone and brush dams.
Arrington's	251	120	.....	.....	2	3	Do.
Haunted Point	253	805	.....	.....	1 8	3	Do.
Birdine	256	971	.....	.....	1 6	3	Do.
Kirkpatrick's	259	135	.....	.....	2 3	3	Do.
Lipscomb's Gin	260	.....	.....	.....	2 3	3	Do.
Black Snake	263	891	.....	.....	1 6	3	Do.
Totals	.....	9,193	1,871	250	.....	.....	

There has been no opportunity of examining the above work at low water since the improvements were made, but as pilots report no deterioration observable, the above table may be assumed to show the present condition of the work.

A little additional work will probably be needed at Turkey Shoals, Sellar's, and Hatcheetigbee, and there are some eight or ten points below Demopolis, including the rock shoals at Pearson's, Turner's, and McGrin's that will require improvement.

For light-draught boats the river below Demopolis is in a fairly navigable condition, and the most urgent need at present is the opening of the channel between Vienna and Black Snake.

It is proposed, therefore, to apply the funds available for expenditure during the fiscal year ending June 30, 1882, after providing an outfit, to improve the river above Demopolis from Black Snake as far as Gainesville, 70 miles above Demopolis.

It is proposed to apply the appropriation asked for fiscal year ending June 30, 1883, to extending the improvement to Vienna, and toward the completion of the improvement below Demopolis.

The amount, exclusive of former appropriations, required for the entire completion of this work is $80,000.

The work when done will not be of a permanent character. Caving banks and falling trees will continue to disturb the regimen of the river, rendering an annual expenditure of $3,000 necessary, in order to keep the channel clear and in good order. The amount that can be profitably expended upon this improvement during the next fiscal year is $35,000. Before this improvement was commenced boats were unable to run to Demopolis at low-water, and below Jackson were obliged to tie up at night, owing to the difficulties and dangers of navigation. Since the improvement of the bars above mentioned, and the removal of the principal log obstructions, light-draught boats have been able to run at all times to Kirkpatrick, 16 miles above Demopolis, without delay at night, except from storms and fog.

The nature and extent of the business interested and to be benefited by the improvement cannot be stated, except approximately, no records being kept of receipts and shipments, except the receipts of cotton in Mobile.

Since cotton, however, is the only marketed production of the country tributary to Mobile, the value of the cotton received there being from $15,000,000 to $18,000,000 annually, while the value of the cotton crop is mostly returned to the producers in plantation supplies, it is evident that the amount of cotton received from the Tombigbee valley will give a fair idea of the nature and extent of the business to be affected by improved transportation facilities of the Tombigbee River. Now the cotton receipts in Mobile from the Tombigbee Valley (including the Warrior Valley) amounted in the season of 1879–1880 to 269,573 bales. Of this amount 92,707 bales arrived by the Tombigbee, and 176,866 bales by Mobile and Ohio Railroad.

The average distance between the river and railroad being about 20 or 25 miles, they are substantially competing lines, and whenever the river is navigable for large boats, a brisk competition ensues, and freight charges are low. River improvements, then, that will have the effect to make this competition continual, will affect the entire commerce of the Tombigbee Valley, whether the actual transit is made by rail or river. That is to say, the whole business of the Tombigbee Valley, amounting in round numbers to 270,000 bales of cotton, worth $13,500,000, with return freight probably exceeding $9,000,000 in value, will be benefited by the improvement.

During the past season the rates, with a full stage of water in the river, were from 50 cents to $1.25 per bale. When there was no river competition the rates by railroad were $3.25 per bale. During the low-water season fully one-third of the crop is sent to market at high rates; hence, with the river improved so as to be navigable at all seasons, there might be expected a saving of at least $1.50 per bale on 90,000 bales, amounting to $135,000, with reductions on up freight enough to raise that amount to $150,000. This may be regarded the minimum annual revenue to be derived by the community after the completion of the Tombigbee River improvement.

This work is situated in the collection district of Mobile, Ala., and Mobile is the nearest port of entry.

Revenue collected for fiscal year ending June 30, 1881, $258,182.10.

Money statement.

July 1, 1880, amount available	$54,786 96	
Amount appropriated by act approved March 3, 1881	25,000 00	
		$79,786 96
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		29,077 70
July 1, 1881, amount available		50,709 26
Amount (estimated) required for completion of existing project		178,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		70,000 00

K 16.

IMPROVEMENT OF TOMBIGBEE RIVER ABOVE COLUMBUS, MISSISSIPPI.

The survey of the Tombigbee River between Fulton and Columbus was completed in 1873, under direction of Maj. W. McFarland, Corps of Engineers. In his report (see Report of Chief of Engineers, 1873, page 548) he recommends the improvement of the river for high-water navigation by the removal of snags, logs, and overhanging trees, &c., and estimates the cost at $35,000.

The sum of $10,000 was appropriated by act of Congress approved March 3, 1873, for the improvement of the Tombigbee River, of which $4,667.05 was expended above Columbus. The balance was used for the lower part of the river.

By act of Congress approved June 18, 1878, an appropriation of $12,000 was made for this portion of the river, and the work assigned to me.

The present project, adopted in 1873, was to improve this river for high-water navigation only, by the removal of snags, overhanging trees, fish-traps, and other obstructions, from Columbus to Fulton, Miss.

Estimated cost of improvement		$35,000 00
The following appropriations have been made for this improvement since placed under my charge:		
Act of Congress approved June 18, 1878	$12,000 00	
Act of Congress approved March 3, 1879	10,000 00	
Act of Congress approved June 14, 1880	4,000 00	
Act of Congress approved March 3, 1881	1,000 00	
		27,000 00
Balance unappropriated		8,000 00

Under these appropriations work on this improvement was commenced at Aberdeen, Miss., in September, 1878, and from that time has been carried on during low-water seasons, to the close of this fiscal year.

The river, with the exception of about 40 miles, which were passed

over during high-water, has been cleared of all obstructions to high-water navigation, by the removal of snags, stumps, overhanging trees, and fish-traps from Columbus to Fulton, Miss., and it is expected that during the next cotton season light-draught boats will ply regularly between the two places, while before the improvement boats could only reach Aberdeen during high freshets.

During the fiscal year ending June 30, 1881, the improvement was carried on from Le Gronis Field, 30 miles above Aberdeen, to within 3 miles of Fulton's Ferry, a distance of 79½ miles by river, the working time being limited to about five months; 397 snags and sunken logs, 3,231 overhanging trees, 5,446 stumps were removed during the year.

The amount of $8,838.72, available from former appropriations, will be sufficient to complete the improvement as contemplated.

With the appropriation of $1,000, made by act of Congress approved March 3, 1881, it is proposed to preserve the improvement already accomplished by keeping the channel free from occasional obstructions caused by freshets, and improve some of the shallowest bars between Columbus and Aberdeen as far as the amount available will permit.

The appropriation asked for fiscal year ending June 30, 1883, it is proposed to expend in the preservation of the improvement during the year, and as the nature of the river will not permit of a permanent completion of the improvement, the amount of $2,000 will probably be required annually to keep the channel open for high-water navigation.

The principal articles of commerce of the section of the country adjacent to this river are cotton and plantation supplies.

During the previous year nearly 2,000 bales of cotton were shipped down the river from between Fulton and Aberdeen; the past year 4,063 bales from between Fulton and Cotton Gin Port, and 8,000 bales from Aberdeen, with corresponding up freights, the amount of which, however, could not be ascertained. The merchants and planters along the river are confident that the trade will increase fully 30 per cent. after the completion of the improvement, and will induce emigration to this section of the country.

An appropriation of $2,000 is asked for the fiscal year ending June 30, 1883.

This work is situated in the collection district of Mobile, and Mobile is the nearest port of entry.

The amount of revenue collected at the port of Mobile during last fiscal year was $258,182.10.

Money statement.

July 1, 1880, amount available	$15,076 73	
Amount appropriated by act approved March 3, 1881	1,000 00	
		$16,076 73
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		6,228 01
July 1, 1881, amount available		9,848 72
Amount (estimated) required for completion of existing project		8,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		2,000 00

K 17.

IMPROVEMENT OF NOXUBEE RIVER, MISSISSIPPI.

The examination of this river, which was provided for by act of Congress approved March 3, 1879, was made during the months of Novem-

ber and December, 1879, from Macon, Noxubee County, Mississippi, to its mouth. The report upon it was made March 6, 1880, and forms a part of the Annual Report of the Chief of Engineers for that year.

Under an appropriation of $12,000, by act of June 14, 1879, the work of improving this river between the county bridge at Macon, Noxubee County, Mississippi, and its mouth, 1½ miles above Gainesville, Sumter County, Alabama, was commenced in August, 1880, and continued until December, 1880. High-water having then set in for the winter months, the work was suspended until March, 1881, when the work of improvement was resumed. Work was commenced in August, 1880, at the county bridge at Macon, Miss., and the river cleared of all overhanging trees, fish-traps, dams, and obstructions, making a clear high-water channel-way to a point about 9 miles below Macon.

The party engaged in this work was transferred to the mouth of the river and work commenced at that point in October and continued until December, 1880. The river during that period was cleared of all overhanging timber, and a clear high-water channel-way made to a distance of about 15 miles above its mouth.

On the recommencement of work in the month of March, 1881, the plant was transferred to the vicinity of the Alabama and Mississippi State line. This move was rendered necessary in order to get above the backwater of the Tombigbee River, which seriously retarded and at times caused a complete suspension of operations.

The river was worked for a distance of 5 miles below Giles' Mill, near the Alabama and Mississippi State line, to a point about 9 miles above the dam, and the river cleared of all overhanging timber and stumps, making a clear high-water channel for that distance.

The river is now navigable during the high-water season from its mouth to a point about 15 miles above its mouth; from the county bridge at Macon, Miss., to a point about 9 miles below the bridge; from a point about 1 mile below the Alabama and Mississippi State line to a point about 13 miles above the State line.

This cleared channel-way can only be used during the season of high-water, as there are several rock and sand shoals which require removal and improving, a number of dams and fish-traps, and an enormous quantity of sunken logs, snags, and other obstructions to be removed from the bed of the river, to give a navigable channel which can be available at any time during ordinary low-water.

During the year the work of improvement for high-water navigation was carried over about 38 miles of river. Owing to the excessive rains which occurred during the progress of the work operations on the improvement were seriously retarded.

AMOUNT OF WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1881.

Overhanging and leaning trees removed	7,851
Large trees trimmed of overhanging limbs	642
Stumps on bank cut level	2,718
Logs on bank cut up (drift)	1,029
Logs removed from bed of river	1,176
Fish-traps removed	2
1 snag-boat and 1 quarter-boat built and fitted as required	

By act of Congress approved March 3, 1881, an appropriation of $8,000 was made for this improvement, and it is proposed to expend this amount during the next fiscal year by continuing the work of improvement as heretofore, so as to make a clear high-water channel from the mouth of the river to the county bridge at Macon, Miss. It is also proposed to render this high-water channel available if possible for navigation during the next coming cotton season. As soon as the river between the points

named is open for high-water navigation attention will then be paid to the bottom of the river, and as far as the balance of funds available will allow, the river bed will be cleared of all sunken logs, stumps, snags, fish-traps, dams, and such shoals as can be improved or removed.

At least $25,000 will still be required to put the river in a condition to be navigable for about seven months of the year, and if further appropriations are granted it is proposed to continue the work of improving the bed of the river and to widen the channel-way by a further removal of timber from the banks of the river.

The work as contemplated would not be permanent and a yearly appropriation of about $3,000 would be required to keep the channel-way clear of logs, snags, and leaning trees, which will be continually falling into and overhanging the river.

These obstructions will be caused by the caving or slipping in after every freshet of the drift and alluvial soil which overlays the rock bluff of the river banks.

As the work of improvement is still incomplete neither commerce or navigation has so far been benefited by the work accomplished. It is thought that substantial benefit will, however, be obtained by the commencement of the next cotton season. The commerce interested and to be benefited by the improvement will be in the great saving of freight on cotton and other produce and plantation supplies.

The shipments over the river after the improvement will be about 15,000 bales of cotton, a large quantity of cotton seed, corn, and other products of the country, and an equal value of merchandise and plantation supplies.

The estimated value of the commerce will be about as follows:

Say, 15,000 bales of cotton, at $50 per bale	$750,000
Cotton seed, corn, and probably a large amount of coal, after the improvement of the water-ways, of the Alabama coal fields.	
Return merchandise and plantation supplies, stock, &c., say 80 per cent. of the value of cotton	600,000
	1,350,000

The work is situated in the collection district of Mobile, Ala., and Mobile is the nearest port of entry.

An appropriation of $25,000 is asked for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$12,000 00	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		12,361 16
July 1, 1881, amount available		7,638 84
Amount (estimated) required for completion of existing project		45,245 25
Amount that can be profitably expended in fiscal year ending June 30, 1883		25,000 00

K 18.

IMPROVEMENT OF PASCAGOULA RIVER, MISSISSIPPI.

An examination of this river was made in 1878, authorized by act of Congress approved June 18, 1878, appropriating 10,000 for this improve-

ment, and a report thereof is contained in Annual Report of Chief of Engineers for 1879.

The plan of improvement then recommended was the dredging of a channel 100 feet wide and 7 feet deep at mean low-water, in connection with a jetty on the west side of the channel, and the clearing of the river of all snags and sunken logs to its head.

The plan adopted, under which operations are now carried on, dispenses with the construction of the jetty and comprises the dredging of a channel 200 feet wide, 7 feet deep at mean low-water through the bar at the mouth of the river, and the removal of snags and overhanging trees throughout its length.

By act of Congress approved March 3, 1879, an appropriation of $14,000 was made for this improvement, and on July 18, 1880, dredging operations were commenced by the contractor, Mr. S. N. Kimball, and continued until January, 1881, when work was suspended, the appropriation being exhausted; 63,000 cubic yards of material were removed and a cut about 5,600 feet long, 90 to 100 feet wide, and 7 feet deep at mean low-tide was obtained. By act of Congress approved June 14, 1880, an appropriation of $20,000 was made for continuing the improvement. On September 9, 1880, proposals for bids were published, and October 9, 1880, four bids were received (abstract of which is hereunto annexed), and Mr. W. Green Mitchell, the lowest bidder, was awarded the contract, at 27 cents per cubic yard. Dredging under this contract was commenced on March 8, 1881; the outfit of the contractor was, however, found inadequate to do the work, and operations were suspended until May 20, 1881 (the interval being consumed in constructing scows and making other necessary repairs to the plant) when dredging was resumed and continued till the close of the year; 12,155 cubic yards of material were removed and the channel widened to 100 feet its entire length, 5,600 feet.

It is expected that by October 1, 1881, the channel will be completed to a width of 200 feet. The east side of the channel has been marked by clusters of creosoted piles for the benefit of passing vessels.

An additional appropriation of $4,000 was made for this improvement by act of Congress approved March 3, 1881, and the project of expending this amount to the improvement of the river by removing snags, overhanging trees, &c., having been approved by the Chief of Engineers, preparations for this work are already in progress.

The appropriation of $20,000, asked for for fiscal year ending June 30, 1883, is proposed to be expended in completing the improvement of the river from its mouth to its head.

The original estimate for clearing the river from Moss Point to its head is $14,000, and after the completion of the channel through the bar about $4,000 will remain available for this purpose, leaving a balance of $10,000 to be provided for the improvement of this section of the river. Between the mouth of the river and Moss Point there are several lumps and shoals, which seriously interfere with navigation from that place, where 13 large lumber-mills, 1 glass and 1 shoe factory are located, and, upon examination, it was found that about 34,000 cubic yards of material would have to be dredged from the channel of the river, at a cost of $10,000, which was not included in the original estimate.

To complete the improvement the sum of $20,000 will be required, and this amount could be profitably expended during the fiscal year ending June 30, 1883.

This improvement will not be permanent in its character. No accurate estimate can at present be made as to the cost of its maintenance, but judging from present indications a small amount compared to its original cost will be required.

The improvement, even in its incomplete state, has already been of vast benefit to the country depending for its trade upon the navigation of this river; the shipments of lumber alone have increased over 10,000,000 feet during the year, with a fair prospect of still further increase; and real estate at Scranton, at the mouth of the river, and at Moss Point, has advanced from 50 to 60 per cent. A canning factory has been established at the former, and a glass factory at the latter place, and several large turpentine distilleries have been started along the river.

The subjoined table, obtained from the custom-house at Pascagoula, will show in detail the extent and value of exports to foreign countries and receipts of revenue.

Pascagoula River is situated in the collection district of Shieldsborough, and Pascagoula is the nearest port of entry. Pascagoula light-house is located at the mouth of the river.

An appropriation of $20,000 is asked for fiscal year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$42,424 20	
Amount appropriated by act approved March 3, 1881	4,000 00	
		$46,424 20
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	23,915 56	
July 1, 1881, outstanding liabilities	79 08	
		23,994 64
July 1, 1881, amount available		22,429 56
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		20,000 00

Abstract of bids received and opened October 9, 1880, relating to dredging at mouth of Pascagoula River, Mississippi.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.	Remarks.
1	S. N. Kimball	$0 30	Ten days after execution of contract.	Four months	
2	Wm. A. Alexander	31	Ninety days	Six months	
3	Geo. C. Fobes & Co	31.3	Not given	Not given	No certificate to affidavit of sureties.
4	Wm. Green Mitchell	27	do	do	Only one surety to bond and no certificate.

List of clearances and statement of lumber shipments, custom-house at Pascagoula, Miss., fiscal year ending June 30, 1881.

Months.	Number of vessels.	Tons.	Superficial feet.	Value.	Cubic feet.
1880.					
July	Foreign 6	2,596	849,147	$11,429 43	.....
	Coast 3	1,250	940,440	11,285 28	87,222
August	Foreign 5	2,716	1,258,119	18,297 53	.....
	Coast 5	2,081	1,450,939	17,402 00	41,886
September	Foreign 5	1,335	826,370	11,629 00	.....
	Coast 3	1,216	752,128	9,036 00	11,550
October	Foreign 7	1,902	1,072,221	16,012 00	.....
	Coast 5	1,949	1,346,669	16,165 00	12,448
November	Foreign 1	208	153,486	2,258 00	.....
	Coast 3	1,250	1,630,550	19,572 00	27,329
December	Foreign 5	1,466	576,225	22,362 00	.....
	Coast 2	804	526,753	6,324 00	200,674
1881.					
January	None.....	.....	.....	.....	.....
February	Foreign 7	3,783	756,900	8,550 38	160,976
	Coast 3	954	711,900	8,544 00	.....
March	Foreign 10	4,630	1,530,069	22,477 69	146,367
	Coast 6	2,931	1,643,084	19,716 00	.....
April	Foreign 13	6,021	2,060,789	28,852 23	168,980
	Coast 7	2,235	1,800,797	21,612 00	.....
May	Foreign 12	4,784	2,048,907	30,446 13	.....
	Coast 2	648	503,355	6,360 00	114,561
June	Foreign 9	4,062	1,213,227	17,695 00	.....
	Coast 6	2,459	1,272,030	15,264 00	125,990
Total	125	58,161	26,750,627	371,113 67	1,097,973

Months.	Number of vessels.	Value.	Ties.	Value.	Custom-house receipts.
1880.					
July	Foreign 6	.....	.....	.....	.....
	Coast 3	$6,492 90	.....	.....	$254 27
August	Foreign 5	.....	.....	.....	.....
	Coast 5	4,016 38	.....	$1,600 00	430 22
September	Foreign 5	.....	.....	.....	.....
	Coast 3	1,650 00	.....	.....	295 76
October	Foreign 7	.....	.....	.....	.....
	Coast 5	1,590 00	7,123	3,562 00	217 60
November	Foreign 1	.....	.....	.....	.....
	Coast 3	3,569 00	.....	.....	517 12
December	Foreign 5	.....	6,121	3,061 00	.....
	Coast 2	27,275 35	8,979	4,770 00	1,138 52
1881.					
January	None.....	.....	.....	.....	1,539 32
February	Foreign 7	23,072 20	.....	.....	.....
	Coast 3	.....	.....	.....	855 65
March	Foreign 10	19,161 00	.....	.....	.....
	Coast 6	.....	.....	.....	1,608 37
April	Foreign 13	23,830 00	.....	.....	.....
	Coast 7	.....	.....	.....	1,835 45
May	Foreign 12	.....	.....	.....	.....
	Coast 2	12,889 36	.....	.....	1,453 84
June	Foreign 9	.....	.....	.....	.....
	Coast 6	15,918 00	5,500	2,800 00	779 38
Total	125	150,464 19	27,723	17,793 00	10,925 50

In addition to above add 35 per cent. to amount of superficial feet of lumber shipped coastwise not reported to custom-house.

Yearly export of charcoal valued at about $75,000.

K 19.

SURVEY OF BLACK WARRIOR RIVER, FROM TUSCALOOSA TO FORKS OF SIPSEY AND MULBERRY, ALABAMA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., August 15, 1880.

GENERAL: I have the honor of submitting herewith a report of a survey of the Black Warrior River from Tuscaloosa to Sipsey Fork, made by Assistant Eugene A. Smith. The survey was made in compliance with the provisions of the act of Congress approved March 3, 1879.

The report shows that the river can be improved by the use of locks and dams, at an estimated cost of $400,533, $760,000, or $1,200,000, according to the character of the work, so as to accommodate the business for which the improvement is especially intended—the transportation of coal in barges from the coal-fields. The enormous quantity of coal in the country through which this portion of the river flows, and its superior quality and accessibility, as shown by this report, proves conclusively the importance of the improvement which would render it available for the use of the government, the people of the Gulf States, and the steamers of all nations employed in the commerce of the Gulf.

The complete improvement, with masonry, dam, and locks of cut stone, at an estimated cost of $1,200,000, which would be of a permanent character when completed, is therefore recommended as required and warranted, and an appropriation of $200,000 is recommended to begin this work.

The river is at present navigable at high-water only, and even then sufficiently dangerous to put a stop to all commerce on the river, although barges have frequently been floated down to Mobile loaded with coal.

The amount of commerce that would spring up with a river improved as suggested is only conjectural, but would evidently be sufficient to warrant the outlay, when it is considered this section of the country and the commerce of the Gulf is now supplied principally from Pittsburgh by a route often closed in the winter months by ice, a contingency to which this would not be liable.

The work is in the collection district of Mobile, and Mobile is the port of entry.

Tracings of index map and profile of the river are forwarded herewith by mail this day, to which, and the report of Mr. Smith, I would refer for full and detailed information.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. EUGENE A. SMITH, ASSISTANT ENGINEER.

UNIVERSITY OF ALABAMA,
Tuscaloosa, January —, 1880.

PLAN OF IMPROVEMENT AND ESTIMATES.

Since the fall of the Warrior River from Sipsey Fork to Tuscaloosa averages but 1¼ feet per mile, it would, if this slope were uniform, be an easy matter to make navigation practicable for light-draught boats by removing reefs and bowlders and constructing wing-dams. But an inspection of the profile shows that the fall is very irregular,

long level reaches being succeeded by abrupt descents; hence a lock and dam system seems the only practicable treatment, and since the river floods rise from 30 to 60 feet above low-water, the locks must be planned with a view to giving passage to boats until the depth of water on the crests of the dams shall be sufficient to allow boats to ascend outside the locks.

The estimates herewith submitted are lower than those usually given for works of similar nature, but I think they are justified from the following considerations:

1st. The business for which this improvement is recommended will be mainly the transportation of coal in barges. Now the capacity of the river below Tuscaloosa will limit the dimensions of such barges and their tow-boats so that they cannot well exceed 120 feet in length by 26 feet beam. Hence I have estimated for lock-chambers 145 feet by 30 feet as being ample to meet the wants of the business.

2d. The locality of the locks and dams will in every case be upon solid ledge with rock-bluff shore connections. This allows one lock wall to be dispensed with, the river bank serving in its stead. It moreover permits timber dams to be used, unfilled with stone, since they can be securely bolted to a rock foundation.

3d. The locks will be located on shoals, where there are but a few inches of water in a low river, consequently the cost of coffer-dams would be trifling and excavation in foundations could be cheaply accomplished. Since the descent of the shoals is quite rapid, there would be several feet fall from the head to the foot of locks. I have estimated for excavating the lock chambers 3 feet at upper end, the depth diminishing to zero, 200 feet below the lock. This will decrease the height of lock walls and of dams, though I have assumed the dams to have the same height as the lift of the locks.

The masonry walls are estimated as being heavy-coursed rubble or range work, the objection to the rough inner face of the walls being met by the use of cast-iron semi-cylindrical flanged fenders bolted to the walls on the inside, the bolts running through the walls and being screwed to washers on the outside. The walls and gates of the locks are to rise 7 feet above the crests of the dams, in order that the locks can be used until the depth of water affords an easy passage over the dams. On Squaw Shoals, however, the fall at any stage of the water is so great that boats in ascending would always have to use the locks; their walls are therefore estimated as rising 10 feet above the dams.

The dams are designed to be of timber bents placed 8 feet from center to center, bolted thoroughly to the rock bed of the river. These bents have a slope of 2 to 1 up stream, and upon them rests the girders which carry the apron of 4-inch plank. The joint between the ends of the plank and the rock bottom is to be closed by bags of concrete, and the whole covered with a clay backing. A plank apron below the dam, inclined 45°, will receive the force of the overflow and prevent erosion. As no ice forms in this river, and as the drift does not run except in high-water, no special protection for the crests of the dams is needed.

The following is the estimate for locks of 10 feet lift:

1,600 cubic yards masonry (including shore connection), at $6	$9,600
50 yards coping, at $12	600
Lock-gates, valves, &c	1,800
Coffer-dam	500
300 cubic yards excavation in foundation, at $3	900
Iron fenders, bolts, &c	900
Contingencies	700
	15,000

For dams, the estimate per running foot, with height assumed at 10 feet, is as follows:

230 feet (B. M.) lumber, at $15	$3 45
Concrete joints	20
Bolts	1 00
Drilling bolt holes	50
Framing and raising	1 00
Clay backing	30
Contingencies	1 55
	8 00

The item for contingencies is large on account of the liability to interruption from floods in building.

The dams would have but one abutment on the river bank, the lock itself forming the other abutment. This abutment is estimated at 150 yards, costing $1,000, which sum is used as a constant in estimating the cost of each dam.

Using the approximate estimate above given as a basis, the following table has

been drawn up giving the probable cost of each lock and dam, and the total cost of the proposed improvement:

No.	Distance from Tuscaloosa.	Distance from preceding lock.	Lift of lock.	Length of dam.	Height of dam.	Cost of lock.	Cost of dam and abutment.	Total.	
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*				
1	0	.....	10	450	10	$15,000	$4,600	$19,600	
2	1	1	10	600	10	15,000	5,800	20,800	
3	1¾	¾	10	1,000	10	15,000	9,000	24,000	
4	9¼	7½	10	450	10	15,000	4,600	19,600	
5	12¾	3½	10	900	10	15,000	8,200	23,200	
6	19¼	6½	10	775	10	15,000	7,200	22,200	
7	22	2¾	10	800	10	15,000	7,400	22,400	
8	26	4	11	1,200	11	17,500	10,200	27,700	Squaw Shoals.
9	26¼	¼	11	1,200	11	17,500	10,200	27,700	
10	27¾	1½	11	1,200	11	17,500	10,200	27,700	
11	28¾	1	10	1,200	10	16,000	9,600	25,600	
12	37¾	9	10	940	10	15,000	8,520	23,520	
13	47½	9¾	10	530	10	15,000	5,240	20,240	Locust and Mulberry Forks.
14	57	9½	10	350	10	15,000	3,800	18,800	
15	68	11	10	240	10	15,000	2,920	17,920	
16	76	8	10	330	8	13,500	3,475	16,975	
17	84¾	8¾	10	250	8	13,500	2,875	16,375	
Sipsey Fork	92¼	7½	.....	.....	.....	.....	.....	.....	
Total								374,330	
Engineering, superintendence, &c., 7 per cent								26,203	
Aggregate								400,533	

It is proper to state that estimates for the proposed work designed with crib dams and lock walls of cut-stone faces would amount to $760,000, and with masonry dams they would reach $1,200,000. The estimates above submitted, however, are thought to be ample for works sufficient for the requirements of the business that may be expected for years to come. The timber dams built of sound, hard lumber, and always submerged, would last for many years, and should the business developed be found to justify the expense, they can be replaced with masonry structures whenever their removal becomes necessary.

Should an appropriation be made to commence this work, it should be with a view to open the river at least as high as Daniel's Creek, 15 miles above Tuscaloosa. This would require the building of five locks and dams, costing $115,000.

NATIONAL IMPORTANCE OF THE WORK OF IMPROVEMENT.

The advantage to Alabama of a navigable river which shall traverse the most important coal field in the State, and which shall afford cheap transportation to the Gulf, not only for the coal but also of the other products of the country, cannot be overestimated. A moment's reflection will show that however great may be the benefit to the State of this work of improvement, the advantages to the national government will not be less.

An unfailing supply of good and cheap coal at the Gulf is of the first importance to the Navy. The supply of coal has hitherto come by the Ohio River. During the winter months, as is well known, traffic upon that river is often interrupted by ice, and we have lately seen that even during the summer months a coal famine may be experienced in the Lower Mississippi and Gulf regions because of low-water in the Ohio.

During the time that the Ohio River is closed by ice, the Warrior would be in its best condition for transporting coal, and there is no likelihood that transportation on this river will ever be interrupted by reason of low-water, for during the unprecedented drought of the past summer (1879) there was always a sufficiency of water in the Warrior, had it been provided with locks and dams, to have furnished uninterrupted transportation for the coal barges.

GENERAL DESCRIPTION OF THE BLACK WARRIOR FROM TUSCALOOSA TO SIPSEY FORK.

Topography.

By a reference to the map and profile accompanying this report, it will be seen that the Warrior, between the Sipsey Fork and Tuscaloosa, has cut its channel altogether

into rocks of the Coal Measures, and that by reason of the varying degrees of hardness of the rocks traversed, the fall between the two points, averaging only 1¾ feet to the mile, is very unequally distributed. The entire fall being 163.84 feet, a fall of 65 feet is found within the first 25 miles from Tuscaloosa; of 107 feet within 31 miles, and of 129.5 feet to the head of the Fork Shoal, about half the distance, or 48 miles. For the remaining 44 miles the difference in level is only a little more than 34 feet.

In accordance with these facts we find the lower part of the river, from the head of the Squaw Shoals to Tuscaloosa much straighter and with comparatively little bottom land. Above these great shoals the course of the river is much more winding; there are great bends with large areas of fertile land, especially where the fall of the river is comparatively slight.

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I am, sir, yours, most respectfully,

EUGENE A. SMITH,
Assistant Engineer.

K 20.

EXAMINATION OF SIPSEY RIVER, ALABAMA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., August 16, 1880.

GENERAL: I have the honor of submitting herewith the report of Assistant J. P. Fresenius* upon the examination of the Sipsey River from near the northern boundary line of Fayette County, Alabama, to its mouth on the Little Tombigbee, near Vienna, an estimated distance of 145 miles. The examination was provided for by the river and harbor act of March 3, 1879.

The report shows this river to be narrow, crooked, shallow, and very much obstructed by snags, logs, overhanging trees, bridges, fish-traps, and mill-dams.

The estimated cost of such an improvement as would enable river steamers to ascend the river during high-water, or about eight months of the year, is estimated at about $145,000. There is no commerce of any consequence on this river at present, but I have no doubt such an improvement as is mentioned above would develop considerable, as there are valuable coal fields on the upper part of the river, and considerable cotton raised in the section of country bordering upon it.

I would respectfully refer to the report of Mr. Fresenius for details.

The river is in the collection district of Mobile, and Mobile is the port of entry.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

K 21.

EXAMINATION AND SURVEY OF COOSA RIVER, FROM THE BRIDGE OF THE SELMA, ROME AND DALTON RAILROAD TO THE CITY OF WETUMPKA, ALABAMA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala.., August 15, 1880.

GENERAL: I have the honor of submitting herewith a report of a survey of the Coosa River, from its mouth up to the lower end of Tuck-

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* Omitted. Printed in Senate Ex. Doc. No. 42, Forty-sixth Congres, third session.

a-league Shoals, made by Assistant Gavin B. Yuille.* The survey was made in compliance with the provisions of the river and harbor act of March 3, 1879, which directed an examination or survey, or both, at the discretion of the Secretary of War, and estimate of cost of improvement proper to be made of the river from the bridge of the Selma, Rome and Dalton Railroad to the city of Wetumpka, Ala. The survey was commenced at the Wetumpka steamboat landing September 17, 1879, and carried on up the river, being much delayed in October, whenthere were twenty days of almost continuous rain, until December 2, 1879, when the regular winter rise compelled a suspension of the work.

The allotment was not sufficient to complete the survey in accordance with the act, but the data obtained on the portion surveyed shows so satisfactory an agreement with the survey made by Henry C. Fillebrown in the fall of 1870, and the estimates for the improvement based upon his survey made to the Chief of Engineers, by Major McFarland, March 23, 1872, that an estimate has been made for the portion not surveyed as well as for that surveyed.

The survey showed, generally, that the river was susceptible of improvement; that the system of improvement should be by locks and dams, a few short stretches of canal, and the removal of rock from the channel at various points; that the improvements once effected in the manner proposed would be of a permanent character, and that the total cost would not exceed $2,649,949. This amount exceeds that made in 1872, which is explained by the more durable character of works now proposed. The improvement is believed to be of great local, national, and international importance, for the following reasons:

It would give an unbroken water communication of about 800 miles from the Gulf of Mexico to the southern border of Tennessee and northwestern border of Georgia. It would supply a large local demand for fuel, iron, and building materials at rates much below the present. It would reduce immensely to the United States the cost of the large supplies of coal and iron which would be required by it on the Gulf of Mexico in time of war, and in time of peace it would result in a saving in the reducion of the cost of these items to the cities of this section generally, and to the steamers, both merchant and war, of all nations navigating the Gulf, which would soon reach the estimated cost of the work.

I would call attention to the report of Mr. Yuille for the details, and particularly to the advantages to be gained by the improvement.

This work is in the collection district of Mobile; Mobile is the port of entry.

The river is not now navigable, and therefore there is no commerce worth mentioning at present on the waters of the Coosa. The amount of commerce that would result from this improvement cannot be computed with any accuracy, but would, in my opinion, be sufficiently large to warrant the expenditure required.

I would respectfully recommend an appropriation of $200,000 to commence the work.

Very respectfully,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

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*Omitted. Printed in Senate Ex. Doc. No. 42, Forty-sixth Congress, third session.

K 22.

EXAMINATION OF THE TALLAPOOSA RIVER, ALABAMA, FROM THE FALLS OF TALLASSEE TO ITS MOUTH.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., January 22, 1881.

GENERAL: I have the honor of submitting the following report of the results obtained by an examination and partial survey of the Tallapoosa River, Alabama, made in accordance with the provisions of the second section of the river and harbor act approved June 14, 1880, and assigned to my charge by letter of June 17, 1880.

The river was found to be susceptible of such an improvement as to give a channel of 80 feet width and 4 feet depth by the removal of snags, overhanging trees, rock and gravel excavation, and the construction of wing-dams and bank protection up to the foot of Tallassee Reefs, and from there up to the Falls of Tallassee, at Tallassee, by the construction of locks and dams, a total distance of 50 miles, at a total estimated cost of $275,125.

Such an improvement as would give a channel of 60 feet width and 3 feet depth at low-water from the mouth up to the foot of the Tallassee Reefs, two miles below Tallassee, a total distance of 48 miles, can be made by the same means mentioned in the previous project, excepting the locks and dams, at a total estimated cost of $40,125.

The present commerce of the river is not worth considering and is carried on by means of small flat-boats, as it is closed to low-water steamboat navigation.

The work is in the collection district of Mobile, Ala., and Mobile, Ala., is the port of entry.

The river is bordered throughout the portion examined by fertile, well timbered land, and from Tallassee up is a magnificent water-power, the utilization of which has been commenced and the development of which is capable of enormous extension.

The estimated commercial products which an improved river will furnish immediate transportation for are about as follows:

13,000 bales of cotton	$650,000
Manufactured cotton, proceeds of 6,000 bales of cotton	535,000
Timber, lumber, building stone, and farm products	25,000
Return freights, coal, iron, merchandise	500,000
Total	1,710,000

If the second project for improvement is adopted, the entire amount estimated can be profitably expended in one year. If a less amount is appropriated, the cost of the work will necessarily be increased.

The examination and partial survey was made by Mr. G. B. Yuille, assistant engineer, and to his report, transmitted herewith, I would respectfully refer for detailed information.

The maps are not yet completed; tracings of them will be forwarded as soon as they can be prepared.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*

REPORT OF MR. GAVIN B. YUILLE, ASSISTANT ENGINEER.

MOBILE, ALA., *January* 5, 1881.

SIR: I have the honor to submit the following report of examination and survey of the Tallapoosa River, from the Falls of Tallassee to its mouth; made in compliance with your previous verbal and letter of instructions of date October 5, 1880. * * *

CHARACTERISTICS OF THE RIVER.

The general character of the Tallapoosa River under examination, from the Falls of Tallassee to its mouth, is such as we usually find characteristic of all rivers passing through a section composed of the drift and alluvial formations; the river assumes a normal condition, due to the nature of its alluvial banks, at a point about 2 miles below the falls, and at the end of the reefs of Tallassee, where it escapes from the unyielding grasp of the metamorphic rocks of its upper portion.

The river generally presents long reaches of fine, open, navigable water, with a width of 200 to 300 feet, and a depth of 6 to 12 feet and upwards, and a current of one-half to three-quarters of a mile per hour. The banks, generally, of the first 30 miles below Tallassee are firm and stable, being largely composed of soft rock or hard clay that is capable of resisting the eroding action of the river, and are usually well protected by a growth of cane, brush, and timber; the occasional exceptions to this general favorable condition of this part of the river is when the width between banks exceeds the normal width for the low-water volume of river, when we find shoal water, with a formation of gravel bars above the surface; also at a few points where island bars have formed upon the nucleus of some early obstruction of timber or rock in the river bed, which has in time formed into a bar large enough to make a partial dam in the river; thereby checking the current, followed by a shoaling of river at the head of island, and the gradual eroding of one or the other of the banks from the increased current through the narrowed channel past the island. In this part of the river we also find reefs of soft rock across the river bed, at four points, which cause shoal and swift water for short distances, but are susceptible of improvement by excavation, without causing any serious reduction of the water level above.

A favorable point for making a cross-section to determine the volume of discharge of river at low-water was found at Fort Decatur Bluffs, which gave a discharge of 1,420 feet per second. From the very favorable nature of this section, and the stage of water when taken, I am satisfied that the result may be accepted as a safe estimate of the mean low-water discharge of the river, upon which may be based a channel-way of 80 feet width and 4 feet depth, with a velocity of 3 miles per hour as the maximum capacity of the river for improvement. This velocity is at least double that found in any other part of the river when the channel-way is in a normal condition. These proposed maximum dimensions of channel-way are therefore confidently assumed as a safe guage of the capacity of the river for improvement. The 20 miles of the river above the mouth is of a more unstable character than the 30 miles of the upper section just described, owing to its passing through a purely alluvial section of country. The banks for most of this distance are of soft, unstable material, yielding readily to the eroding action of the river, when unprotected by a growth of brush or cane. We find, therefore, this portion of the river more liable to shifting bars and shoals from the ever-recurring caving in of the banks, bringing with them timber and brush, that lodge in the river, forming snags, and masses of timber, about which sand-bars form, causing further disturbance of the river channel and consequent new encroachments on the banks.

This lower portion of the river is susceptible of large improvement at once by the removal of snags and fallen timber that has accumulated from neglect and non-use for navigation since the close of the late civil war. Its ultimate permanent improvement will be assured by a thorough system of bank protection, when 4 feet depth of channel, at low-water, can be maintained, as in the upper section.

PLAN OF IMPROVEMENT.

In considering the plan or scale of improvement of which the river is susceptible, it becomes necessary to take into consideration, not only the immediate traffic expected, but that also likely to be developed by the improvement of the river to its full capacity. To meet these requirements it is proposed to submit two scales or grades of improvements, the first to be for a channel depth of 3 feet at low-water, and a width in rock excavation of 60 feet, the channel to extend to the head of open river at the foot of Tallassee Reef, 2 miles below the factory.

The second plan to be for a channel depth of 4 feet, and width in rock excavation of 80 feet, or the full capacity of the river at low-water. The improvement to be extended to the foot of the Falls of Tallassee, by a lock and dam system, over the Tallassee Reefs, for the last 2 miles.

In the execution of the improvement on the first plan, it is believed that the works proposed, to give a channel depth of 3 feet, will, in most cases, give the 4 feet of the second plan when a sand-bar has to be removed by a wing-dam and dike, since the result expected from such works is always, in a measure, experimental and dependent much upon the after care and protection of the works; so that an increased cost for the second plan is only an amount expended to secure the permanence of the first; consequently the increased cost of the second plan is due almost entirely to the extension of the improvement over the Tallassee Reefs to the foot of the Great Falls. The ultimate extent of the improvement of this portion of the Tallapoosa River is undoubtedly indicated by the formidable obstructions to navigation presented in the Great Falls of Tallassee, where we find a fall of 52 feet in a distance of about 300 feet. This formidable obstruction to navigation, however, offers an amount of power for manufacturing purposes that is equaled by but few situations, possessing an estimated power of six thousand horses, only about one-eighth of which is at present utilized by the Tallassee factory. In view of this great source of manufacturing wealth concentrated here, it is questionable whether there is any good reason why this point should not be regarded as practically the head of navigation, and the river above this utilized for manufacturing purposes, for which it possesses an immense capacity.

The plan proposed for the improvement of the river is in the use of wing-dams and dikes, built generally of brush and gravel, stone-filled cribs, and piling; the banks protected by brush and gravel and riprap stone, when procurable—all the works to be amply reinforced with heavy stone from upper river when opened to boats. The soft rock reefs to be removed by excavation; also such hard gravel bars, as may require it.

OBSTRUCTIONS TO NAVIGATION.

Following the order of survey, we will commence the description of the various obstructions to navigation of the river at the Falls of Tallassee, the practical head of navigation, and describe each in its order of mileage, by map measurement, from Mobile, the initial point of the river system of Alabama.

Tallassee Reefs, 405 miles (see detailed map, sheet No. 1), commencing at the foot of the Great Falls of Tallassee we find a pool of deep water extending about one-quarter of a mile, from 300 to 600 feet wide, and reported to be 60 feet deep in places; at the lower end of which the river widens and shoals into a succession of reefs and broken water, making its way over the obstructing ledges of the hard metamorphic rocks of this section. At the lower end of these reefs the river narrows to about 300 feet upon reaching the soft rock, and assumes the character of an alluvial stream with high banks and quiet water; this point being the beginning of the open river lying below. We find a fall of 32 feet in the surface of the river from the pool, at the foot of the Great Falls, to the slackwater of the river at lower end of reef. To extend navigation to the foot of the Great Falls will require the construction of dams and locks, when the demands of commerce require it. The estimate, therefore, for this part of the work will not be included in the estimated cost of the proposed river improvement now under consideration.

Tuckabatcha Shoals, 403½ miles.—Immediately below the last of the rock ledges of the Tallassee Reefs, and one-fourth mile above the Tuckabatcha place, is situated a series of small rock ledges and gravel bars, with collections of logs and snags obstructing the channel, extending over a distance of one-quarter of a mile. The improvement indicated here is the cutting out of portions of these ledges, the removal of the logs and some of the heavy gravel, with the building of two short wing-dams from the left bank, where the river is of undue width; training the current along the right or west bank, which is of soft rock at its base, but capable of resisting the eroding action of the river.

The removal of this shoal will extend the navigation to the foot of the Tallassee Reefs proper, and establish the head of open river navigation contemplated in this improvement.

Green's Bar, 402½ miles (see detail map No. 2).—Passing through a reach of fine, open river for one-quarter of a mile below the Tuckabatcha place, we reach Green's Bar No. 2, a gravel bar extending from the right or west bank, deflecting the channel to the left, through which ample water is found, except at the entrance at head of bar, where there is scant 3 feet, and that only close along the point on left bank. Since the deflection of the channel from its true line down along the right bank must now be regarded as an accomplished fact by the formation of this bar and the new channel on the left bank, the improvement proposed is the building of a dam closing the passage of water on the right side, and the extension of bar up stream by a dike from upper end to contract the entrance of chute along the left bank, with the removal of snags and overhanging trees, and the breaking up of the hard gravel at head of bar.

Walahnee Creek Bar, 401½ miles.—Situated about one-fourth of a mile above the mouth of Walahnee Creek. Ample water and uniform width of river was found from

the bar above to this point, where there is a widening of the river, and a low sand-bar on the left side of the channel, with a shallow and swift chute along the right or west side; this chute is much obstructed by logs and overhanging trees, with a depth of only 2 feet at head of bar. The improvement here indicated is the removal of logs and overhanging trees, with the construction of a wing-dam from the left bank above, with a connecting dike to the head of bar below, leaving a channel way of about 200 feet wide, along the right bank of river, also the extension of the dike some 200 feet below the present bar.

Council House Shoals, 401 miles.—From the last named bar the river presents a fine navigable channel, till a point is reached half a mile above the mouth of Uforbee Creek, designated as "the Council House Shoals," where the giving way of bluff on right bank has caused a widening of river bed, with a consequent shoaling of channel to about 2 feet, and the farther deflection of the channel to the left. Relief will be afforded here, by the construction of a wing-dam from right bank, to contract the channel at the shoal point.

Uforbee Creek Bar, 400⅛ miles.—At the mouth of Uforbee Creek, entering the river from the east or left side, a bar has been formed on the right; although ample water was found through the chute along the left bank past the bar, it is much obstructed by logs and trees lodged and gathering from the breaking down of the left bank. The improvement required here is the removal of trees and snags from the channel, protection to the left bank, and the building of a heavy crib dike to train the direction of the discharge of the creek into the river and a protecting dike on the bar, opposite the mouth of creek, on the right bank, to confine the channel to a suitable width.

Buzzard Bar and Shoal No. 2, 399½ miles.—This bar and shoal commences at a point about half a mile below the mouth of Uforbee Creek, and extends for about 1 mile; the river in this distance is of undue width with a dispersed channel through and among low sand-bars and islands; the depth of water found at several places was as low as 3 feet, all, however, in soft and shifting sand bottoms. The improvement proposed here is the contraction of channel width by wing-dams and training dikes, and the closing of island chutes by brush and gravel construction, up to ordinary low-water heights; this will secure a channel depth of from 5 to 6 feet through the shoal.

Green's Bar No. 1, 398 miles.—From Buzzard Bar and Shoal a fine open river was found with ample water in channel all the way to Fort Decatur Bluffs. All the improvement required is the removal of snags and timber from the channel, and overhanging trees from the banks, except at a point one mile above Fort Decatur Bluffs, when Green's Bar No. 1 is found on the left side of river, having a narrow chute along left bank which should be closed to add its volume to the main channel as security for its future preservation.

Fort Decatur Bar, 397 miles.—In the short bend of the river at Fort Decatur Bluffs, we find a shoal bar for a short distance, lying between the deep water above and below, having a fall in the surface level of 10 inches in a distance of 500 feet, and a depth on crest of bar of 2½ feet. This condition of the river at this point is due to the greatly increased width of river bed caused by the washing away of the point of soft bluff on the right, and the shortening of its course by the movement from its old channel on the left of the island bar, to the right of it some 300 or 400 feet. The improvement indicated here is to protect the right bank from further inroads from the river action, the contraction of the present channel to a width of 200 feet, and the excavation of the hard gravel on the crest of bar.

Wallahatchee Reef, 395½ miles.—From Fort Decatur Bluffs to a point one-fourth of a mile above the mouth of Wallahatchee Creek, on the right, we find a fine open reach of river, having ample depth and free from obstructions other than a few snags and overhanging trees; at this point is found a reef of soft rock extending partly across the river from the right bank, upon which scant 3 feet of water was found for a distance of about 200 feet. This will require the excavation of about a foot depth for the distance named to give an open channel, all the improvement required.

Goodwin's Reef, 395 miles (see detail map, sheet No. 2).—At one-fourth of a mile below the mouth of Wallahatchee Creek we find a more extensive reef of soft rock extending across the river, or rather a succession of detached ledges that extend some 300 feet in distance, and project in some places above the surface, at other points having a depth of ½ of a foot to 1½ feet with deep holes of 7 and 8 feet between, with swift and broken water for 200 or 300 feet, and a total fall in surface of 26 inches in 2,000 feet between slackwater above and below. The improvement can be effected by the excavation of a channel through these irregular ledges for a distance of 250 feet.

Snag Reef, 394 miles.—At upper end of bend in river to the left, one mile below Goodwin's Reef, there is found a ledge of soft rock extending from the right bank two-thirds across the river, over which the water makes a ripple, and in the passage-way of the open third of channel there is a large fixed snag obstructing the passage of boats, though 5½ feet of water was found in the gap. The improvement required here is the removal of the snag and blasting off of the point of rock ledge to make the gap wider; deep water found above and below the ledge.

Zimmerman's Reef, 393¾ miles.—Quarter of a mile below the last-named reef is found one of a more serious character. On the right-hand side of river is found a shoal of soft rock, extending 500 feet in length, and about half way across to left bank, connecting with left bank by irregular ledges, through which the channel is found of about 100 feet width, and a depth of one foot, with broken and swift water, having an estimated fall in 1,000 feet, from slackwater above reef to slackwater below, of 18 inches. The river is widened out on the right and left hand sides at the reef, the channel being found, on the left side, obstructed at the upper end by the irregular ledges above mentioned, and a mass of gravel immediately below, extending in all about 400 feet, when ample water is again reached in the channel along the left bank. The improvement here indicated is the cutting out of a sufficient gap through the ledges of rock, and the removal of the gravel below the ledge.

Sunken Reef, 390¾ miles.—Ample water found in river from last-named reef to a point about 2 miles below the mouth of Calubee Creek, where soft rock, in detached masses, was found, with only 2 feet of water on them in places. These lumps reached nearly across the river at two points, and only perceptible by a slight ripple in water surface. Deep water found within 25 feet, above and below. Their removal will effect the relief required.

Jordan's Shoals, 389½ miles.—From the last-named obstruction, good river and ample water was found to the lower end of Jordan's Bend, where, from the giving away of bank on the right, and a consequent widening of channel, a slight shoal is forming. Three feet of water was found on crest of shoal, on soft sand bottom. The building of a small wing-dam from the right bank will remove the forming bar and give uniform water through the bend.

Goose Bar, 388¾ miles.—Quarter of a mile below Jordan's Bend is found "Goose Bar," or "Island," the base of which is of beds of soft rock, causing a widening of the river and the forming of a gravel bar upon it, with a channel on each side. The best channel was found on the east or left bank, although not so wide as that on the right; the deepest water was found there, giving 3 feet at the shoalest points. The improvement proposed here is the closing of the right chute by a dam, and the removal of some of the gravel at the crest of bar, and building a dike down on the bar, to concentrate the scour of the river through the left chute. The left bank, being also more solid in character than that of the right, will better withstand the eroding action of the river. A fall of 14 inches was found from slackwater above to slackwater below the bar, an amount insufficient to cause any disturbance of regimen in the river above on the removal of crest of bar.

Hall's Bar, 387¾ miles.—Passing over a fine reach of open river of ample depth, 1 mile below the last-named bar, we find "Hall's Bar," commencing just below Reese's Ferry. This bar, like the last, is based upon a strata of soft rock, that is capable of withstanding the scour of the river, so that the channel has been deflected to the left bank, and formed a large gravel bar, connected with the right, throwing the entire river to the left of bar. At the head of bar the shoal gives a depth of about 3½ feet, with a hard gravel and rock bottom. It is believed that the breaking up of the hard and compact gravel, and some of the soft rocks at the head of the bar, with the extension of a dike, for 200 feet at upper end of bar, will effect, by the scour of the river, all the deepening of the channel needed.

Clarkson's Shoals, 383½ miles.—Found a fine open river all the way from Hall's Bar, through the bend, above Caleebahatchee Creek, through Clarkson's Bend to a point half way between the latter place and the mouth of Line or Oakfuskee Creek, when a shoal was found, having only scant 4 feet of water, caused by a widening of the river and a deposit of soft sand. A short dam from right bank of 75 or 100 feet will cause the sand to move out, and give all the relief required.

Dawson's Shoals, 382¾ miles.—About 1 mile below the mouth of Oakfuskee or Line Creek there was found a small shoal spot, opposite the mouth of a branch flowing into the river on the right side, upon which was found scant 4 feet water. A short wing-dam from near the branch will effect the removal of the shoal.

Dawson's Bar, 382½ miles.—About a quarter of a mile below the last-named shoal there is found a gravel bar, with a chute or channel on the right and left. A good channel was found on the left, having 4 feet of water on crest of bar, at entrance of chute. To secure the permanence of this channel, it is proposed to place a short wing-dam from the right bank, placed a little above the bar, and connecting with it by a dike, so as to close the right-hand chute and effect a scour in the left-hand chute.

Hatcheechubee Creek Shoal, 378 miles.—From Dawson's Bar on, down the river, through Holtzclaw's Bend, 1 mile below, ample water was found; also through the straight reach below to Turner's Ferry, and thence past the mouth of Hatcheechubee Creek to a point 1 mile below where the open river is obstructed by a shoal of sand and gravel lodged upon ledges of soft rock, having a depth in channel of only 2 feet. From the unyielding nature of the river bed here, the channel has become greatly widened, with a consequent shoaling of the depth. The improvement indicated is the placing of a wing-dam of about 150 feet in length at the upper end of shoal from the left bank, extending

a dike from its outer end, some 600 feet down stream, concentrating the river in the reduced channel along the right bank. The two soft rock ledges to be cut out, and the heavy gravel removed from the proposed direct channel.

Judkin's Shoal, 377¼ miles.—In the upper end of Judkin's Bend we find a shoal spot, with only 2½ feet water; this is caused by the breaking down of the right bank, and consequent widening of river allowing the water to escape across the point into the river below in time of floods. The remedy here required is the protection of the right bank and the placing of a small wing-dam to narrow the channel. This it is believed will give the improvement desired.

Buzzard Bar No. 1, 377 miles.—Immediately below Judkin's Bend a large gravel bar is found, with channel on the right, that on the left being entirely closed in low stages of the river. The true place for the channel past the bar is, undoubtedly, along the left bank, but as the entire river now passes to the right in low-water, and ample water is found through it, we have to accept it as it is or incur a large outlay in the opening of the one on the left. All the improvement needed at this place is the removal of the snags and fallen timber from the channel on the right.

Andrews' Bar, 376 miles.—In the bend to the left of river, 1 mile below the last bar, we find a widening of the river by the giving way of the banks on the right, with the formation of a bar on the point, with a shoal and obstructed channel by collection of trees, forming shoal spots; this shoal water continues some half mile below the bend, where the river is of undue width. The improvement indicated is the removal of snags and fallen timber from the channel, protection to the banks, and the contraction of the river where wide by wing-dams.

Lucas' Bend Shoal, 373 miles.—From the last-named bar we find a fine open river of ample depth, on down past midway bar, in the bend next below; then fine water continues on through the sharp bend at the old Augusta Ferry; thence through the fine reach of good river till we come to the upper end of Lucas' Bend, where we encounter a shoal place in river, from its having widened out through the giving way of the bank. Sufficient depth of water was found on the shoal at the time of examination, but as the banks are giving way, it is only a question of a season or two before the causes now in operation will cause a very serious shoaling of the river; it is, therefore, neeessary to provide for this protection.

Moulton's Bar, 372 miles.—At the lower end of Lucas' Bend we find a bar on the right bank, with the channel on the left. This channel is obstructed with snags and timber from the breaking down of bank on the left; 4 feet of water is found at head of bar, and it is believed that the removal of the logs from the channel will give the necessary depth of water past the bar to deep water below.

Little Bar, 371½ miles.—Half a mile below the last-described bar is found a small bar in process of forming, caused by the widening of river by the giving way of bank, on right; only 2½ feet of water was found. The improvement can be secured by the protection of the banks and the placing of dam to contract the channel, with the aid of some gravel excavation on the crest of bar.

Shackelford's Bar, 370½ miles.—Just below Henderson's Ferry, on the right bank, we find a sand-bar with the channel along the left bank. Three feet depth of water was found at the head of bar, with ample depth through the passage to deep water below. The channel is much obstructed by snags and timber from the caving bank along the left. The channel would be put in a navigable state by the removal of the snags and lodged timber and the contraction of channel at upper end of bar by a short wing-dam.

No Name Bar, 369½ miles.—About 1 mile below the last-named bar is a point bar on the right bank, with channel along the left. Ample depth of water found at upper end, but the channel past the bar is much obstructed by lodged trees and snags, causing shoal spots. The removal of the timber from the channel, and the placing of a short wing-dam near the lower end to aid the scour of the current will, it is believed, give all the relief required at this point.

Alligator Bar, 369 miles (see detail map, sheet No. 2).—One-half a mile below the last doint we enter upon an obstructed part of the river, extending about a mile in length, known as "Alligator Bar," at its upper end. The chief point of obstruction is at head of bar, where, from a widening of the river, we have a shoal upon a hard gravel bottom, and the channel much dispersed, till it concentrates in one main chute down along the left bank, where there is generally sufficient depth of water, but the channel much obstructed with snags and fallen trees from the adjacent bank, which is in a broken and yielding condition. The improvement indicated here is a proper contraction of the water into one main channel at the head of bar, by closing the chute behind the mud or willow island, and the training of the current by wing-dams and dikes into one channel, the breaking up of the hard gravel and the thorough removal of the snags and lodged timber from the river, with such protection to the eroding banks as the nature of the case will admit.

Alligator Hole, 367½ miles.—Immediately below Alligator Bar, in a short bend of river to the left, is found a point known as "Alligator Hole," where the channel is almost closed by an accumulation of snags and drift timber, with the banks breaking

up from the swift water caused by the obstructed channel. The removal of the timber from river will afford the necessary relief for immediate navigation, but the banks will require protection before a permanent condition of improvement can be maintained.

Bald Bar, 364½ miles (see detail map, sheet No. 2).—From the last-named place a fine open and deep river was found to a point three-fourths of a mile below Judkin's Ferry, Young's Bend. This bar, extending from the right bank, throws the channel down along the left, at entrance of which is found scant 4 feet of water, with hard gravel bottom, and swift water through the chute past the bar; channel much obstructed by snags and lodged timber, and bank on left breaking down under the action of flood waters. The relief required here is the contraction of channel at head of bar, the breaking up of the compact gravel, and the thorough removal of snags and lodged timber.

Twin Bars, 363½ miles.—Immediately below the bend to the left of the river, 1 mile from the last-named bar, we encounter a succession of bars and shoal places, much obstructed by timber, affording, however, sufficient depth in channel-way at present, but in a very broken and irregular shape, due to the masses of lodged timber, and breaking down of banks. The improvement required here is the removal of all logs and lodged timber, the proper training of the channel-way by dams and dikes, and such protections to the banks as will check their waste from the river action.

Island Bar, 362½ miles.—Passing over a fine reach of good river for 1 mile from the Twin Bars we reach an island bar, with a chute or channel on each side; that on the left (the largest) presents the true channel, as being the best in direction to enter from the river above; 3¾ feet depth was found at upper end of island, with ample depth all the way through chute on the left, much obstructed, however, with snags and lodged timber, and the bank on left giving way at lower end. The improvement indicated here is the closing of the right-hand chute, and placing a wing-dam at point above, on the right, to contract the river at the upper end of left-hand chute; also, the breaking up of the hard, compact gravel at head of chute, and the removal of timber and snags from channel, with protection to banks on left.

Henry's Bar, 361½ miles (see detail map, sheet No. 3).—Passing over 1 mile of fine open river we reach an obstruction to navigation at a point in upper end of Henry's Bend, 1 mile above Hatchet's Ferry. Here we find the river widened out by the giving way of the banks on the left, and the channel shoal and filled with lodged timber and forming sand-bars. The channel is divided into two, the main one on the left and a small one on the right. Only about 2 feet of water was found in channel-way, and the bank on left giving back under the eroding of the water in flood stages of river; also, the right bank along the lower end of the Henry Bend below the shoal of the bar. The improvement here indicated is the closing of the right-hand chute of the island bar and the contraction and training of the channel by wing-dams and dikes into a width that will give the required depth for navigation, the removal of all timber and snags from the channel, and such protection to the banks as will maintain the present position of river as far as possible.

Hatchet's Bar, 360½ miles.—One mile below the last-described bar and immediately below the ferry of that name, is founp a sand-bar on the right bank of the river with main channel on the left. Ample water is found past the bar till near the lower end, where, from the widening out of the river, shoal water was found. The remedy here required is a short dam at lower end of bar, and the removal of the snags and logs from channel.

Grey's Shoal, 360 miles.—One-half a mile below Hatchet's Ferry, extending above and below the site of Grey's Old Ferry, we find a number of shoal places in river, from the widening out of the channel by the giving way of the banks on the left. The improvement required here is the closing of the chute on the right of the island bar, and the contraction of the channel at several points by wing-dams and protection to the banks.

The Cut-off, 359½ miles.—Passing over a half mile of river below Grey's Old Ferry we reach the Cut-off, where, from the unstable character of the low bank on the right, a long-threatened cut-off of the river into a bend below has taken place, and has so far established itself that it may now be regarded as the river channel proper, notwithstanding the disturbance it has created in the old régime of the river, having shortened the river at this point about 1¾ miles, causing a very swift current in the cut-off that is making havoc of the adjacent soft banks, which will only cease when the new channel has arrived at a normal condition, adapted to the volume of water with its new velocity. The channel in the cut-off is very much obstructed by snags and timber; also the river above the cut-off along the right bank, where the trees of the breaking-down bank are lodged along the side and in the channel, by which the river is very much obstructed. Recognizing the cut-off as an accomplished fact, the old river channel should be closed up entirely, a small amount of water yet passing that way at low-water stage; a dam should be put across the old river bed on the left, and a thorough removal of the lodged timber.

Fort Jackson Cut-off, 358¼ miles.—Passing through the new cut-off, we enter upon a

fine open reach of river, extending 1¼ miles to a point where the bends of the Tallapoosa and Coosa rivers approach within a quarter of a mile of each other. During high-water the waters of each unite across this space, and as the rise of either is in advance of the other, there is a very strong current across this space, which is gradually making a channel that will in time cut through to low-water levels, and thereby damage the present régime of each river to the destruction of one or the other, from this point to their present junction below. It is, therefore, proposed that a suitable protection against such a result be made.

Fort Jackson Bend Shoals, 357½ miles.—Immediately below the threatened cut-off referred to above, the river banks of the right hand are in course of gradual erosion by the river action; being mostly formed of alluvial deposits, present very little resistance. The giving way of the bank has widened the river here for near a mile in length, which presents now several shoal places of about 2½ feet depth; at some points the forming bars on the left bank have maintained sufficient depth in channel when there are no snags and timber lodged to prevent the action of this natural process. To secure a channel of sufficient water through this place will require the aid of several short wing-dams from the left bank, the removal of timber from river, and protection to the banks on the right.

The mouth of the Tallapoosa River, 356 miles.—From the point last mentioned to the mouth of the river, ample water was found, though much obstructed by snags and lodged trees. Immediately at the mouth a bar has formed in the channel of the Coosa, and divided the channel of the Tallapoosa into two chutes, the main one passing almost square into the Coosa; the other, or left-hand one, passing into the Coosa between the bar and left-hand bank, having a direction more in line with that of the latter, and possessing the best direction for the river to enter the Coosa. The right-hand chute offered the deepest water at time of examination, but its direction into the Coosa being almost at right angles to the line of current of latter creates a deposit of sand and gravel in mid-river that in course of years has made a dam, causing very swift and shoal water for several miles below, to the injury of its navigation. To remedy this situation, it is proposed to build a strong dike of cribs, with stone filling, from the point on the right in a line down stream of the Coosa, so as to train the current of the Tallapoosa through the left-hand chute of the bar, and thus gradually blend the currents of the two rivers and secure a united and harmonious channel. This completes the list of obstructions to navigation in the Lower Tallapoosa River, and it is believed that the treatment proposed in the plan of improvement for the various obstructions will secure the desired depth of water for navigation.

As before stated, two plans or grades of improvement are proposed, the first to be a depth of 3 feet and a width of 60 feet in the soft rock cuts, with a width of 200 feet in open river channel-way, which grade can be mainly attained by the thorough removal of snags and lodged timber and the training of the channel at a few points by dams and dikes, with the excavation of ledges of soft rock at three or four places. This can be accomplished by a very moderate outlay, and secure to the section through which the river passes an immediate result that will probably give the desired relief to the business of the section now heavily taxed by the high and discriminating rates of combined railroad monopolies. This plan contemplates the opening of the river for 3 feet draught to the head of open river, at the foot of Tallassee Reefs, 2 miles below the Falls of Tallassee.

The next plan offered is to secure a grade of improvement up to the full capacity of the river, which, at a discharge of 1,420 feet per second, as found at Fort Decatur, will give a maximum channel at the lower-water stage of 80 feet width and depth of 4 feet, with a velocity of 3 miles per hour. This velocity is almost double that found in portions of the river where the width was about 200 feet and the depth from 4 to 5 feet. This plan also contemplates an open river navigation to the foot of Tallassee Reefs, and the extension, by locks and dams, over the reefs to the foot of the Falls of Tallassee. The large item of increased cost of this second plan is in the extension of the navigation over the reefs by slack-water navigation; otherwise the increase is due to enlarged channel-way through the soft rock cuts, and the re-enforcement of the work of the first plan, which is also a legitimate item to be added to the cost of the first grade of improvements for its permanent establishment.

ESTIMATE OF COST.

First Plan.—To give 3 feet depth, with 60 feet width, in soft rock cuts, and 200 feet in open river, the following estimate is presented:

Cost of snag-boat, tackle, and outfit	$2,500 00
Pay-roll, subsistence, superintendence, and contingencies, at $1,100 per month, six months' service	6,600 00
Summary of detailed estimate for wing-dams, dikes, bank protection, gravel and soft rock excavation	31,025 00
Total cost, first plan of improvement	40,125 00

Second Plan.—To extend navigation to foot of Tallassee Falls by lock and dam, with channel in open river of 200 feet width and depth of 4 feet, with a width in soft rock cuts of 80 feet, locks 210 feet in length, and 40 feet width in chambers, and 4 feet water on miter sill; lock lifts 8 to 10 feet.

Cost of the first plan for open navigation	$40,125 00
To which add the estimated cost of the re-enforcement of the same and the additional excavation of soft rock	25,000 00
Four locks of stone masonry, at $35,000 each	140,000 00
Three stone and crib dams	40,000 00
Guard-walls of canal, stone and masonry	30,000 00
Total cost, second plan of improvement	275,125 00

The above approximate estimates are presented as ample for the execution of the work, should it be prosecuted without unnecessary delay; as all such works are subject to deterioration and waste when left for a season in an incomplete state, and can only be resumed again at a cost for repair of waste.

It is recommended that, in obtaining an appropriation for the work, an amount be asked for sufficient to finish to completion such portions in the plan of improvement that will afford immediate relief to the obstructed river, and open, to a moderate extent, navigation of the entire lower river by one season's work. This could be accomplished by an appropriation of $25,000, covering the estimated cost of snag-boat outfit and pay-roll for six months' service, with an amount sufficient to cut out the soft rock reefs and the improvement of some of the most needful of the shoals and bars.

MAPS AND PROFILE.

Accompanying this report please find one general index map, scale 2 inches to 1 mile, showing connection of Tallapoosa River improvement with the Alabama and Coosa rivers, and adjacent centers of commerce; also, three sheets of detail surveys of obstruction, scales 100 and 300 feet to inch; with profile of Tallassee Reef.

DISTANCES.

The following map distances show the connections of Tallassee with adjacent commercial centers of trade:

	Miles.
Tallassee to mouth of Tallapoosa River	50
Tallassee to Wetumpka, via Tallapoosa and Coosa rivers	61
Tallassee to Montgomery, via Tallapoosa and Alabama rivers	68
Tallassee to Selma, via Tallapoosa and Alabama rivers	150
Tallassee to Cahata coal fields, via Alabama and Cahata rivers	266
Tallassee to Mobile, via Tallapoosa and Alabama rivers	406

COMMERCIAL STATISTICS.

The section of country tributary to Tallassee, the head of navigation of the Tallapoosa, and country adjacent to the line of river, is situated in the collection district of Mobile, Alabama.

The lands lying contiguous to the river, from the mouth to Tallassee, present a continuous succession of rich bottom lands, now largely cultivated in cotton and corn, presenting as fine a body of cotton lands as can be found in any portion of the cotton belt of Alabama. The uplands, adjacent to the river, also present good arable lands, largely cultivated in cotton, corn, and the small grains, presenting also good stock range in the more hilly portions that are covered with forests of as good pine timber as any in the State, the more northern portions of which, in the vicinity of Tallassee, are yet in a virgin state, for lack of cheap transportation to market.

At the head of open river navigation, where the river is permanently obstructed by the rocks of the metamorphic formation, presenting the immense water-power resources heretofore referred to, we have also an unlimited supply of building stone immediately available upon the opening of cheap transport by water. This building stone has already been extensively used in the buildings at Tallassee. The large cotton-mill there is built of it, presenting a substantial piece of work, the stone, in some cases, being almost a pure granite, of a strong and durable character. The facilities offered in cheap transportation of this material will introduce its use for building purposes at all points where such material is required along the river lines, and doubtless develop a large business.

The following tabular statement of commercial products, actual and estimated, of

the section tributary to the proposed river improvement is presented, gathered from the best sources of information at command:

9,000 bales of cotton from Tallassee and river below, at $50 per bale	$450,000
Manufactured cotton in cloth, yarns, rope, &c., from Tallassee factory, proceeds of 6,000 bales of cotton	535,000
Estimated value of timber, lumber, building-stone, corn, fruit, vegetables, and other farm products	25,000
Return freights in coal, iron, merchandise, &c	500 000
4,000 bales cotton for Tallassee factory	200,000
Total commercial value	1,710,000

The requirements of the present and immediate prospective necessities of the commerce on the Tallapoosa River will be fully met by the proposed plan of improvement submitted; that is, the cleaning of the river channel of obstructions to secure a depth of 3 feet at low-water past the bars and through the reefs to the head of open river at the foot of Tallassee Reef, 2 miles below the town of Tallassee. The further improvement to give a depth of 4 feet will be brought about by the same works in course of time, and with a small additional amount of cost, when the needs of commerce require it. The proposed scale of improvement will also fully satisfy the expectations of the citizens in the relief it will afford. To conclude, I beg leave to state that I found much interest manifested by the citizens in the success of the work, and was given all the aid and co-operation necessary when solicited. To Messrs. Sistrunk and Jordan, of Tallassee, and the officers of the Tallassee Manufacturing Company, I acknowledge myself indebted for aid in making up the statement of commercial statistics.

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Respectfully submitted.

GAVIN B. YUILLE,
Assistant Engineer.

Maj. A. N. DAMRELL,
Captain, Corps of Engineers, U. S. A.

K 23.

EXAMINATION AND SURVEY OF CAHABA RIVER, ALABAMA, FROM CENTREVILLE TO NORTHERN BOUNDARY OF BIBB COUNTY.

OFFICE OF UNITED STATES ENGINEERS,
Mobile, Ala., February 1, 1881.

SIR: I have the honor of submitting the following report of the results of an examination and partial survey of the Cahaba River provided for by section 2 of the river and harbor act approved June 14, 1880, and assigned to my charge by letter of June 17, 1880.

A survey was made in September, 1874, of that portion of the river between Centreville and its mouth, a distance of 88 miles, the report of which is contained in the Annual Report of the Chief of Engineers for 1875.

The present survey continued the previous one from Centreville to Shade's Creek, or the north boundary of Bibb County, and included a line of levels on the lower portion, to supply a deficiency in the survey of 1874, and an examination to see if any marked changes had taken place since that time.

The two together show that the river can be improved by the removal of snags and overhanging trees, construction of wing-dams, and cutting through shoals, so as to give a channel of navigable width and 3 feet depth at low-water, from its mouth up to Centreville, 88 miles, at an estimated cost of $195,000; and from Centreville up to the northern boundary of Bibb County, 23.667 miles, by locks and dams, at an estimated cost of $382,000. The total distance would be 111.667 miles, and

the total estimated cost $577,000. The improvement would give steamboat navigation below Centreville and barge above.

There was formerly considerable commerce on the river, but the obstructions are such now that no use is made of it.

The extent of trade that would be built up can only be conjectured, but it is reasonable to suppose that it would be considerable, from the fact that the river would afford cheap transportation for about 50,000 bales of cotton, valued at $2,500,000, and return supplies of $2,000,000; would give the shortest water-route from the Alabama coal fields to the Gulf, and would save to every consumer of coal on the Gulf coast from $1 to $6 on every ton of coal used by them, and probably would save $4 or $5 a ton on all coal that is at present used by the United States on the coast or in the Gulf, or might be required in time of war. It would also afford an outlet for iron, building stone of excellent quality, and limestone, both ordinary and hydraulic, in all of which the country bordering the Upper Cahaba is extremely rich.

The report of Mr. C. B. Percy, the assistant, who was intrusted with the survey, is transmitted herewith, and to it I would respectfully refer for all details.

The maps and tracings will be forwarded as soon as completed.

The sum of $200,000 can be profitably expended during next fiscal year.

This river is in the collection district of Mobile, Ala., and Mobile is the port of entry.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain, Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*

REPORT OF MR. C. B. PERCY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., January 1, 1881.

MAJOR: I herewith respectfully submit the following report, together with accompanying papers, of the examination and survey of that portion of the Cahaba River from Centreville, county seat of Bibb, to Shade's Creek, the northern boundary of said county, undertaken according to your letter of instructions dated August 1, 1880.

The papers consist of—

1. An index map, scale $\frac{1}{31680}$, showing the course of the river, with its tributaries; also the position and extent of the more important shoals and rapids.
2. Detail sheets Nos. 1–11, scale $\frac{1}{2400}$, being maps of the shoals, rapids, islands, topography of adjacent country, and the hydrography of the river.
3. Profile of the Cahaba River from Centreville to Shade's Creek.
4. Cross-sections at various points.

SURVEYS.

The first survey of the Cahaba River with a view to improving the navigation was made September, 1874, from Centreville to its junction with the Alabama, a distance of 88 miles, under the charge of Mr. M. J. Mack, assistant engineer. His report is to be found in the published reports of the Chief of Engineers, 1875, Part II, page 11. The survey ordered August, 1880, was a continuation of that of 1874, extending to the north boundary of Bibb County.

Organizing the engineering party in Mobile, I proceeded to Centreville, and commenced the survey August 14, taking my initial point 40 feet south of the ferry, 2,567 feet south of the O point of survey of 1874, and in section 26, township 23 north, range 9 east.

* * * * * * *

DESCRIPTION OF THE RIVER.

The distance from Shade's Creek to Centreville by map measurement is 23.667 miles; the total fall is 121.4 feet.

Centreville, a town of 300 inhabitants, is situated at what is considered the head of navigation, 88 miles from the junction with the Alabama River, with total fall of 127.4 feet, making the total fall from Shade's Creek to the mouth 248.8 feet in a dis-

tance of 111.667 miles. There are but two settlements on the river, Cahaba, formerly the capital of the State and once a prosperous town, now rapidly disappearing, and has dwindled to an insignificant village of 100 or 200 inhabitants, and Centreville, the county seat of Bibb. Above Centreville for 11 miles the country is pretty well settled and generally cultivated; beyond that point to the Shelby County line there are but few farms immediately on the river and very little cultivated land.

The river below Centreville has not been navigated by steamers since 1849, owing to the construction of two railroad bridges. The produce is now either carried by wagons to the railroads or by barges during the season of high-water down the river. The only recorded attempt of a steamboat to go above Centreville was in the spring of 1880; a small stern-wheel boat of no capacity, and with but few horse-power, endeavored to surmount the Centreville shoals, but resulted in total failure.

No agricultural or commercial statistics of Bibb County have been kept, only surplus crop raised for market being cotton, of which about 50,000 bales, I think, would be a fair estimate for Bibb, Perry, and Dallas Counties, through which the Cahaba flows; this crop was formerly flat-boated to the Gulf, but now seeks railroad transportation, at enormous cost to the planters. The means of getting produce or stock to market are so limited that the people of Bibb County may be considered as practically cut off, and the consequence is but little surplus besides cotton is raised.

The country above Centreville is rugged, but with fine lands, an excellent quality of timber, and in almost its primitive state. Should the river be improved, a large lumber business would immediately spring up, and with its splendid climate, magnificent water-power, and inexhaustible iron deposits and coal measures, I know of no portion of Alabama or of the Southern States offering superior inducements to manufactories of all kinds.

The river between Centreville and Shade's Creek may be divided into four sections.

1. From the foot of the Little Cahaba Shoals to Centreville, a distance of 10.22 miles, with a fall of 22.7 feet. Of this amount it slopes 9.2 feet in 8.42 miles, a smooth, quiet stretch, with no obstructions to navigation but two or three fish-trap dams and some bowlders here and there, very few snags, and no leaning trees of any consequence. From the head of Centreville Shoals to Centreville the remaining portion of this section, a distance of 1.8 miles, the river falls 13.5 feet, or at the rate of 7.5 feet per mile, is very swift and dangerous, full of large rocks, ledges of abrupt fall, islands covered with willows, and terminating 400 feet above Centreville, with a fall of 2½ feet.

The general course is southwest, then south, flowing through a narrow strip of Silurian stratum, which lies south and southeast of the Cahaba coal measures. In this stratum occur the principal iron ores, marbles, and other limestones, many of which are sufficiently pure for lime making, some almost pure carbonates; others possess, to considerable degree, characteristics of hydraulic limestones. At two or three localities on the river building stones of excellent quality may be obtained, especially at Burkhalter Creek, station 334. At this point, both above and below, for some distance, extend immense marble bluffs, and on the creek mentioned, half a mile from the river, a quarry has been opened and to some extent operated, the stone splitting smooth and even into flags, of any thickness desired. The stone from this quarry was used in the public buildings at Marion, Perry County.

The bed of the river is rock, covered, here and there, with layers of gravel and sand. The bank on the west side, for the first two miles above Centreville, is liable to overflows during very high freshets, but above this point bluffs, of height varying from 50 feet to 150 feet, rise perpendicular from the water's edge, while on the other we find the cultivated lands, with high banks varying between 30 and 50 feet, slope, 1 to 1, and with receding hills well covered with timber.

The regime of the river is permanent; no shifting shoals nor washing banks, but few islands, and those of small extent. Its width at Centreville ferry is 183 feet; at Station 42+95, 194 feet; at 100+80, 268 feet; at 308+91, is reduced to 167 feet. Its narrowest point is just below the foot of Little Cahaba Shoals, and is 156 feet. Its average may be taken at 200 feet. Its general course is approximately straight, with no sharp bends.

The growth of timber is principally oak, hickory, ash, juniper, and chestnut.

Second division extends from foot of Lily Shoals to the foot of the Little Cahaba Shoals, a distance of 4.91 miles, with a total fall of water surface of 53.8 feet, or an average of 10.9 feet per mile, mainly confined to the Big Shoals, Caffee Creek Shoals, and Baily Reach Rapids. The Silurian formation extends as far as Pratt Creek, station 591, a distance of 11.2 miles. Here a sharply-defined fault occurs, and the limestone ceases. Above this point the river flows through the coal measures. The general course is still south and southwest, and its character considerably changed. The bed is solid rock, covered with large bowlders; the shoals longer and falls more frequent; the deep pools shorter; the stream more turbulent, and the banks very high and steep on both sides; the adjacent lands not cultivated, the topographical features becoming very rugged; the vast timber forests untouched, and now largely intermingled with groves of pine of immense size and superior quality. At station 547 the Cahaba receives from the east its

principal tributary, the Little Cahaba, a shallow, rapid stream of about 100 feet in width, and on it are located the principal deposits of the brown hematite that are to be found in such immense quantities in the hills and valleys of the Cahaba, and estimated at 200,000,000,000 of tons, with fuel and flux lying parallel, and separated by only a few miles throughout its length. The width of the river still averages about 200 feet, reaching a maximum on the Big Shoals of 550 feet, the depth here varying from 3 inches to six inches, and current very rapid, with a fall 28.3 feet in a distance of 1.55 miles, resuming the normal width of 200 feet above Caffee Creek until we reach the Pine Island and Baily Reach Rapids, where it falls 14.5 feet in 2,300 feet, and there we find a width of 505 feet. From here to the Lily Shoals the current is rapid, but with good depth of water; the banks are exceedingly high and covered with fine pine growth; the bed of the stream is divided into narrow, deep channels by ridges of sandstone parallel to the current, the ridges at a low stage being covered with about 3 inches of water and a growth of grass and water lilies. Above the Big Shoals three large creeks flow in from the west, viz, Caffee Creek, Little Ugly, and Big Ugly. Upon Little Ugly the traditions of the people locate a silver mine, and in a cave, near where the line crosses the creek, have been found implements for reducing, and said to have been of Mexican origin.

3. From the foot of Long Island Shoals to the foot of the Lily Shoals, a distance of 4.4 miles and a fall of 20.3 feet, the general features remain the same, the country very thinly settled and very little cultivation on the river. The same geological formation as in Division 2, but with more frequent outcroppings of coal on the river.

4, and last. From the northern terminus of the survey to the foot of Long Island Shoals, a distance of 3.37 miles and fall of 24.45 feet. The length of the shoals and pools, with the slope of surface per mile, and total fall of each, is shown in the following table:

Table of Shoals and Pools of the Cahaba River.

Names.	Distance in feet.	Distance in miles.	Total Fall.	Rate per mile.
Shade's Creek Pool	1,858	.18	.267	.76
Caffee Fishtrap Shoals	4,100	.78	3.142	4.065
Lock Pool	6,800	1.29	.450	.37
Half Mile Rapids	2,050	.39	8,357	21.49
Cane Creek Pool	950	.18	.167	.93
Long Island Rapids	1,820	.35	12.165	35.00
Reach Shoals	4,480	.85	5.019	5.90
Reach Pool	1,400	.27	.565	2.09
Daly Creek Shoals	1,700	.32	4.208	10.15
Daly Creek Pool	6,755	1.28	1.598	1.25
Lily Shoals	3,803	.72	8.944	12.45
Hill's Camp Branch Pool	2,942	.56	.142	.25
Hill's Camp Branch Shoals	1,300	.25	5.123	20.47
Ugly Creek Pool	1,650	.314	.910	.30
Bailey Reach Rapids	2,300	.43	14.519	33.76
Caffee Creek Pool	2,800	.53	.735	1.39
Caffee Creek Shoals	425	.08	4.343	54.29
Wyman Pool	2,475	.47	.967	2.06
Big Shoals	5,050	.96	22.265	23.19
Little Cahaba Shoals	6,350	1.20	4.799	4.00
Shultz Creek Pool	44,350	8.40	9.205	1.07
Centreville Shoals	5,000	.94	8.414	9.00
Kennedy Fish Trap Falls	3,550	.67	2.474	3.72
Davidson Fish Trap Falls	1,090	.21	2.645	12.72
		23.65	121.443	

DISCHARGE OF CAHABA RIVER.

The rainfall being so great during the whole time of the survey, the river was considerably above the low-water mark, and at only two places, Centreville Ferry and Cane Creek, could the discharge be determined with any degree of accuracy. Fortunately these points were well situated, one being at the initial point of the survey, the other near the upper terminus at Station 1091+98, above all tributaries of any considerable size or discharge.

At Centreville Ferry, water at lowest stage; width 183 feet, the mean velocity determined from the greatest surface velocity by formula (1) page 674 Rankine Civil Engineering, 159 feet per second.

The discharge (mean of five trials), 714.476 cubic feet or 4,455.14 gallons per second.

2. Station 1091+98, 30 feet above the mouth of Cane Creek and 20.8 miles from Centreville Ferry, width of river 287, water about 6 inches above lowest water mark. Discharge (mean of three trials), 341.7 cubic feet or 2,131.67 gallons per second.

CAHABA COAL MEASURES.

To show the great benefit to the State, and to the Southern coast, to be derived from the improvement of the Cahaba River, I present the following brief description of the coal measure; the information being condensed from the paper of Mr. R. P. Rothwell read before the American Society of Engineers, 1873, reports of the State Geologist, Birney's Hand-book of Alabama, and personal observation made during the survey.

There are three distinct coal basins in Alabama, viz: the Warrior, Cahaba and Coosa, which, from the geological structure, we are compelled to conclude were once continuous. It is to the central member of the group that our attention is especially directed, which, on account of its being the most southern, most accessible by water navigation, and presenting the greatest variety, as well as the best quality of coals, will undoubtedly become, in the event of the Cahaba River being improved, one of the principal coal producing districts in America, and until the river is improved the Cahaba coal field will probably remain untouched.

In the southern portion of the field reached by the present survey the measures are regular, with a width of about 12 miles and an inclination of 6 to 10 degrees on the western limits, 12 to 15 degrees on the Cahaba River, in the neighborhood of the Lily Shoals, and increasing rapidly, until toward the eastern limit the rocks are dipping from 45 to 75 degrees, becoming vertical in a few places.

The field is limited on its southern and eastern side by the fault referred to in another part of this report, which cuts off the coal measures and brings to the surface the Silurian strata belonging 7,000 to 8,000 feet below them. The greater inclination of the Cahaba beds causes them to outcrop within a limited area, and as there is a greater total thickness on the eastern and southern sides, as there are a greater number of beds and greater variety of coals than exists in any part of the Warrior or Coosa basin.

From the topographical features of the country a railroad crossing three fields would necessarily be graded considerably above the streams and therefore the coal would have to be raised by vertical shafts to the level of the road, thus greatly enhancing the cost of mining, and there would be less inducement to the opening of the lowest water level, a difficulty done away with by the improvement of the river. The surface is everywhere, as before stated, covered with a virgin growth of yellow pine, chestnut and oak, together with other valuable timber.

NUMBER AND THICKNESS OF THE COAL BEDS.

The coal measures consist of some ten or twelve veins of variable thickness of clean coal, *i. e.*, from 2 feet upward, with several of less thickness, varying from 15 to 18 inches. They are distributed in two groups, the lower and upper. The lower group contains seven or eight beds, varying in average thickness of from 3 to 7 feet, making an aggregate of from 30 to 35 feet of clean coal, while the upper, or Montevallo group, along the eastern edge, contains three or four beds with an aggregate of 12 feet. But the enormous thickness of the measures between the upper and lower groups renders the latter inaccessible where the former exists, so that the maximum thickness available will not exceed 30 to 35 feet. Therefore, taking the area of the Cahaba field to be 250 square miles, the average thickness will possibly not exceed 15 feet.

The veins are generally free from shale partings, forming single benches of coal, and therefore well adapted to clean mining. The maximum thickness of any vein yet opened in the Cahaba field is that of the Big seam on Little Ugly Creek, about half a mile west of the river, and is equal to about 9 feet, but is of little value on account of its excessive softness. Another vein worked to some extent during the rebellion has a thickness of 7 feet, that of the Gholsen seam.

The following is a list of some of the principal workable beds on or near the Cahaba River as far as the survey extended. The first indication of coal was observed just above the mouth of the Little Cahaba, and the first and most southern opening is in section 9, township 24, range 10 east, near Station 655 + 50; the same vein crossing the river and forming the eastern portion of river bed at Station 687 + 45, and crops out above the surface on east bank, and said to be 7 feet thick, opened in 1853, and abandoned on account of inability to get the coal to market, the company having met with serious loss in trying to transport it down the river.

The next one going north is the Thompson lower mine in the Gholsen seam upon Pine Island ranch section 10, township 24 south, range 10 east. This coal produces a coke (made in open air) of excellent quality, and was hauled in large quantities to the railroad during the war for shipment to Selma. At the close of the war several hundred tons were left at the mouth of the pit, and the farmers and blacksmiths for miles around are at the present day supplying themselves with fuel from this pile. Its excellent quality is fully attested by the fact that, after an exposure of more than 15 years to the rains and warm sun of this climate, it still burns freely in grates. The thickness of the seam is 4 feet.

Then we find the opening in the "Big Seam" on Little Ugly Creek, fractional section 28, township 22 south, range 5 west, and about half mile west of the river. This opening was abandoned on account of the extreme soft character of the coal rendering it of little value. Thickness is about 8 feet 6 inches.

Then the Thompson seam, on which is located the Thompson and Herndon mines, up the Thompson upper coal branch, thickness of — feet.

Coke seam sections 12 and 13, township 22 south, range 5 west, openings on Daly Creek, where large quantities of coke were made and used with great success in casting cannon and heavy ordnance at the Confederate Government foundry, located at Selma. Thickness of this seam is about 3.5 feet.

On Cane Creek, outcroppings are visible; also on Bear Creek and Lick Branch. At the head of Long Island Rapids and just below the mouth of Cane Creek, 3 feet above the water's edge in the bluffs, and on the west bank of the river, is a vein 3 feet thick. Besides these there are nineteen or twenty veins mentioned in Mr. Rothwell's report and that of Professor Smith, proving an abundant, in fact, an almost inexhaustible, supply of coal in easily accessible beds to the river, and of good workable thickness. The following table, taken from the reports referred to, proved that the Cahaba coals are of fine quality, distinguished for their dryness, little ash, and great amount of fixed carbon, some making an excellent coke for the blast furnace; some are dry burning coals, not coking, and would work raw in the furnace, and in comparison with the Indiana and Ohio coals, which rank among the best furnace fuels in the country, the analysis would seem to indicate that the Cahaba coals are superior to these, and to be an exceptionally pure coal.

They contain, as seen from the table, a small amount of sulphur in the form of a sulphuret of iron, varying considerably in different veins, but in the best sufficiently free from it to be used raw in the blast furnace and in all cases producing coke of great purity.

Cahaba coals—R. P. Rothwell's analysis.

	Number of samples.						
	1	2	3	4	5	6	7
Specific gravity	1.22	1.29	1.29	1 38	1.29	1.28	1.12
Moisture	1.66	1.58	1.91	1.93	2.05	2.13	2.54
Volatile combustible matter	32.28	32.60	32.65	32.84	33.47	30.86	29.44
Fixed carbon	63.04	62.62	63.91	59.64	62.20	64.54	66.81
Ash	2.02	3.20	1.53	5.59	2.28	2.47	1.21
Total	100	100	100	100	100	100	100
Sulphur as sulphate	.097	.223	.071	1.001	.118	.320	.073
Sulphur as sulphuret of iron	.428	.727	.559	2.779	.523	1.160	.455
Sulphur in coke	.....	.....	.....	.....	.....	.....	.214

	Number of samples.			Mean of ten analyses of Cahaba coals from eight veins.	Mean of fourteen analyses of Indiana coal. Cox.	Mean of six analyses of Ohio bl'k coals.
	8	9	10			
Specific gravity	1.28	1.25	1.35	1.26	1.24	1.266
Moisture	1.78	2.14	2.13	1.98	5.2	4.54
Volatile combustible matter	30.60	31.92	27.03	31.47	34.8	34.61
Fixed carbon	66.58	63.68	66.22	63.92	57.2	58.68
Ash	1.09	2.26	4.62	2.63	2.6	2.17
Total	100	100	100	.....	.....	.....
Sulphur as sulphate	.085	.....	.114	1.06	.....	0.87
Sulphur as sulphuret of iron	.479	.....	.388			
Sulphur in coke	.223	.....	.....	.....	.....	.....

No. 8 from coke veins.
No. 9 from Gholsen vein.
No. 10 from Montevallo vein.

The cost of mining will vary at the different veins according to the thickness, amount of shale, nature of roof, location of beds, &c., but $1.50 per ton (Professor Smith, State geologist) will cover all expenses, including interest, wear and tear of improvements, &c. This is about the cost per ton at the Pratt Mines. The cost in barge will vary from $1.50 to $2, and with the river made navigable, transportation to the gulf will not exceed 75 cents, thus enabling the coal to be put upon the Mobile market at a cost not exceeding $3.

The incalculable benefit of improvement of the Alabama system of rivers, and especially those flowing through the coal fields, is clearly shown by the coal famine and the exorbitant prices (as high as $13 per ton) that have prevailed here and elsewhere throughout this State and the extreme South during the present season 1880 and 1881.

IMPROVEMENT OF THE UPPER CAHABA RIVER.

From the gaugings and the table of slopes of the water surface, and topography of the banks of the Cahaba River, it is clearly evident that the only method of improvement is by slackwater navigation.

This will require locks and dams to be placed in the river at different points, backing the water to the next dam or to deep-water, thus dividing the total distance into several pools of slackwater. The bed of the river for the first 11 miles is of excellent quality of limestone, and in the remaining portion, wherever locks are located, it is a firm, hard, and compact sandstone. The bank on the lower portion on one side is bluffs and on the other steep, with no danger of washing or caving. On the upper portion they become high and very steep on both sides, covered with fine yellow pine and other valuable timbers. The width is generally uniform.

We therefore see that our dams can be securely fastened to the bed and firmly rooted in the banks, thus assuring the permanency of any improvement.

There is close at hand an abundance of good stone of which to construct the locks and abutments, also for the cribs of dams and ripraps throughout the whole distance surveyed.

The shoals and rapids averaging from 300 feet to 550 feet in width, we can locate the locks and dams in such position, generally, that the sectional area of water passing over their crest will equal the average area in the narrower portions, and the locks are designed to be of such height that when they become submerged the water will flow over the crest of the dam without causing much more than a ripple.

The locks are to be composed throughout of the best first-class masonry; the abutments sustaining the thrust of the gates to be of good rubble masonry, and all to be laid in the best hydraulic cement. The gates to be of timber and worked by machinery. The wing-walls and tie-walls to be made of cut masonry facing and rubble backing. The dams to be of composite of wood and stone, with uniform width of 10 feet on top and slope of 1 to 5 toward the back. The channel excavation to be 60 feet broad with clear depth of 3 feet, and when the excavation is just below lock, forming approach to same, the width is to be reduced to 30 feet.

The dimensions of the locks are designed to be the same as those on the Warrior, so that the barges and tugs may be used on either, viz, 90 feet in length between the miter sills and 22 feet clear at the bottom, with a depth of prism of draught of 3 feet. In the lower portion of the river the locks are designed to have such lift that the whole breadth of the river will have a clear depth of 3 feet. On the upper portion where the locks are close together and the reaches shorter, the locks are to be uniform in lift and the channel is to be excavated where necessary.

LOCK AND DAM NO. 1.

The first lock is located at Station 7, a distance of 0.14 mile from the initial point of the survey, upon the Davidson fish-trap dam, or the first obstruction to navigation above the town of Centreville (see sheet No. 1). The island can be utilized in constructing dam and the lock located in the chute on west side of the river. The great width of river at this point gives a good discharge over crest of dam, and the lock will have to be calculated as submerged, as the oscillation of the river at this point exceeds 37 feet. The following is the estimated cost. Height of wall 26 feet; lift of lock 13 feet; length of dam 242 feet; height of dam 13 feet.

Rock excavation for foundation of lock, 162 cubic yards, at $2	$324 00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry in lock, 1,580 cubic yards, at $16	25,280 00
Rubble masonry in lock, 277 cubic yards, at $8	2,216 00
Two pair timber gates and machinery at $1,300	2,600 00
Timber framing in place, 9,910 linear feet, at 20 cents	1,982 00
Crib sheeting in place, 25,000 feet B. M., at $40	1,000 00
Crib stone in place, 1,104 cubic yards, at $3	3,312 00
Riprap stone in place, 542 cubic yards, at $2	1,082 00
	38,296 00

LOCK AND DAM NO. 2.

The location of this lock is at the head of Centreville Shoals, Station 88+50; level reach of 1.54 miles (sheet No. 2). Foundation of lock and dam is on rock bed with lock on east bank 1.68 miles from Centreville Ferry. This lock reaches the long, smooth, deep stretch of water of 7.07 miles. The following is the estimated cost. Height of wall 16 feet; lift of lock 7 feet; length of dam 345 feet, and height of dam 9 feet.

Rock excavation for lock, 100 cubic yards, at $2	$200 00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry for lock, 1,008 cubic yards, at $16	16,128 00
Rubble masonry for lock, 191 cubic yards, at $8	1,528 00
Two pair gates and fixtures at $800	1,600 00
Crib framing in place, 9,020 linear feet, at 20 cents	1,804 00
Crib sheeting in place, 27,000 feet B. M., at $40	1,080 00
Crib stone in place, 1,013 cubic yards, at $3	3,039 00
Riprap stone in place, 410 cubic yards, at $2	820 00
	26,699 00

LOCK AND DAM NO. 3.

This should be located at or near Station 462, giving a level reach of 7.07 miles above lock No. 2, and is 8¾ miles above Centreville Ferry and 3,000 feet above Pratt Ferry. Foundation of rock; height of wall 20 feet; lift 11 feet; length of dam 190 feet, with a height of 12 feet.

Estimated cost.

Rock excavation for foundation of lock, 100 cubic yards, at $2	$200 00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry in lock, 1,418 cubic yards, at $16	22,688 00
Rubble masonry in lock, 213 cubic yards, at $8	1,704 00
Two pair gates and fixtures at $950	1,900 00
Crib framing in place, 6,500 linear feet, at 20 cents	1,300 00
Crib sheeting in place, 15,300 feet B. M., at $40	612 00
Crib stone in place, 697 cubic yards, at $3	2,091 00
Riprap stone in place, 352 cubic yards, at $2	704 00
	31,699 00

LOCK AND DAM NO. 4.

This is located at Station 605+25, near the foot of the "Big Shoals," at the head of a level reach of 2.71 miles, and 11.46 miles from Centreville Ferry. Its foundation is sandstone. Height of wall 18 feet; lift 7 feet; length of dam 210 feet, and height 9 feet. (See sheet 7.)

Estimated cost.

Earth backing for lock, 1,000 cubic yards, at 50 cent	$500 00
Hammered masonry in lock, 814 cubic yards, at $16	13,184 00
Rubble masonry in lock, 197 cubic yards, at $8	1,576 00
Two pair gates and fixtures at $900	1,800 00
Crib framing in place, 5,335 linear feet, at 20 cents	1,067 00
Crib sheeting in place, 16,400 feet B. M., at $40	656 00
Crib stone, in place, 548 cubic yards, at $3	1,644 00
Riprap stone in place, 250 cubic yards, at $2	500 00
	20,927 00

LOCK AND DAM NO 5.

This is located at or near Station 638 (see sheet 7), level reach of 0.63 mile and 12.09 miles from Centreville; about middle of Big Shoals. Foundation, sandstone; height of lock wall 16 feet; lift 13 feet; length of dam 300 feet, and 10 feet high.

Estimated cost.

Rock excavation, 664 cubic yards, at $1	$664 00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry in lock, 908 cubic yards, at $16	14,528 00
Rubble masonry in lock, 142 cubic yards, at $8	1,136 00
Two pair gates and fixtures at $850	1,700 00
Crib framing in place, 9,275 linear feet, at 20 cents	1,855 00
Crib sheeting in place, 25,200 feet B. M., at $40	1,008 00
Crib stone in place, 890 cubic yards, at $2	1,780 00
Riprap stone in place, 356 cubic yards, at $1	356 00
	23,527 00

LOCK AND DAM NO. 6.

Located at Station 682, Caffee Creek Shoals (see sheet 7), at the head of an 0.83 mile level reach, and just above where the coal vein crosses the bed of river and forms a portion of bed on eastern side. A channel is cut to the lock entrance, and the water is lowered in lower reach by about 1 foot, thus exposing, at extreme low-water, the coal seam. The foundation of lock and dam is sandstone; height of wall 15 feet; lift 10 feet; length of dam 400 feet, and height 6 feet. This lock is 12.92 miles above Centreville Ferry.

Estimated cost.

Rock excavation, 582 cubic yards, at $1	$582,00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry in lock, 796 cubic yards, at $16	12,608 00
Rubble masonry in lock, 115 cubic yards, at $8	920 00
Two pair gates and fixtures at $750	1,500 00
Crib framing in place, 6,340 linear feet, at 20 cents	1,268 00
Crib sheeting in place, 24,000 feet B. M., at $40	960 00
Crib stone in place, 618 cubic yards, at $2	1,236 00
Riprap stone in place, 120 cubic yards, at $1	120 00
	19,694 00

LOCK AND DAM NO. 7.

Located at Station 723, Baily Reach Rapids (sheet No. 7), with a level below of 0.78 mile. This lock brings the Gholsen seams on Pine Island Branch and big seams upon Little Ugly Creek within reach. The foundation here is sandstone, with high bluffs on east bank and gravel bar on west, furnishing excellent material for crib fillings. The height of wall 19 feet, and lift 13 feet; length of dam 354 feet, and height 11 feet.

Rock excavation, approach to lock, 248 cubic yards, at $1	$248 00
Rock excavation, foundation to lock, 442 cubic yards, at $1	442 00
Earth backing to lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry, 1,269 cubic yards, at $16	20,304 00
Rubble masonry, 141 cubic yards, at $8	1,128 00
Two pair gates and fixtures, at $900	1,800 00
Crib framing in place, 11,540 linear feet, at 20 cents	2,308 00
Crib sheeting in place, 32,000 feet B. M., at $40	1,280 00
Crib stone in place, 1,152 cubic yards, at $2	2,304 00
Riprap in place, 528 cubic yards, at 75 cents	396 00
	30,710 00

LOCK AND DAM NO. 8.

Located at Station 851 on Adams' fish-trap dam (sheet No. 8). Bed of river sandstone, banks high and steep on both sides, level below 2.42 miles; height of walls 12 feet, with lift 7 feet; length of dam 310 feet, and height 5 feet.

Rock excavation for lock, 163 cubic yards, at $1	$163 00
Earth backings for lock. 1,000 cubic yards, at 50 cents	500 00
Hammered masonry, 613 cubic yards, at $16	9,808 00
Rubble masonry, 139 cubic yards, at $8	1,112 00
Two pair gates and fixtures, at $600	1,200 00
Crib framing in place, 3,760 linear feet, at 20 cents	752 00
Crib sheeting in place, 16,680 feet B. M., at $40	667 00
Crib stone in place, 384 cubic yards, at $3	1,152 00
Riprap, 104 cubic yards, at 75 cents	78 00
	15,432 00

LOCK AND DAM NO. 9.

Located at Station 893, foot of Lily Shoals (sheet No. 9), and at the upper end of a level of 0.80 mile in length. Lock No. 9 will carry the levels to coal veins on Lily Shoals, Bear Creek, Lick Branch, and the coke seams upon Daly Creek, thus reaching the principal seams of the "Lower Cahaba Group." Height of wall 18 feet, lift of lock 10 feet; length of dam 305 feet, and height 10 feet.

Estimated cost.

Rock excavation for lock, 100 cubic yards, at $1	$100 00
Earth backing for locks, 1,000 cubic yards, at 50 cents	500 00
Hammond masonry, 1,096 cubic yards, at $16	17,536 00

Rubble masonry, 192 cubic yards, at $8	$1,536 00
Two pair gates and fixtures, at $900	1,800 00
Crib framing in place, 8,980 linear feet, at 20 cents	1,796 00
Crib sheeting in place, 25,650 feet B. M., at $40	1,026 00
Crib stone in place, 1,000 cubic yards, at $3	3,000 00
Riprap in place, 400 cubic yards, at $2	800 00
	28,094 00

LOCK AND DAM NO. 10.

Located at Station 1003, on Daly Creek Shoals (sheet No. 9), at the head of a level 2.08 miles in length. Height of wall 18 feet, lift 10 feet; length of dam 320 feet, and height 10 feet.

Estimated cost.

Rock excavation for lock, 244 cubic yards, at $1	$244 00
Earth backing for lock, 1,000 cubic yards, at 50 cents	500 00
Hammered masonry for lock, 1,096 cubic yards, at $16	17,536 00
Rubble masonry, 192 cubic yards, at $8	1,536 00
Two pair gates and fixtures at $900	1,800 00
Crib framing in place, 9,470 linear feet, at 20 cents	1,894 00
Crib sheeting in place, 26,850 feet B. M., at $40	1,174 80
Crib stone in place, 1,008 cubic pards, at $3	3,024 00
Riprap in place, 412 cubic yards, at 75 cents	309 00
	28,017 00

LOCK AND DAM NO. 11.

Located at Station 1074, foot of "Long Island Rapids" (sheet No. 10), and at the head of level 1.34 miles in length. Lock No. 11, with the channel excavation at the head of these rapids, will carry slackwater navigation to the mouth of Cane Creek, as far as it would be necessary, unless the improvement is designed to be extended beyond the barren measures to the Helena mines and other veins of the Upper Cahaba Group. Height of wall 18 feet, lift 10 feet; length of dam 320 feet, and height 10 feet.

Estimated cost.

Rock excavation for lock, 244 cubic yards, at $1	$244 00
Earth backing for lock, 1,000 yards, at 50 cents	500 00
Hammered masonry, 1,096 cubic yards, at $16	17,536 00
Rubble masonry, 192 cubic yards, at $8	1,536 00
Two pair gates and fixtures at $900	1,800 00
Crib framing in place, 12,575 linear feet, at 20 cents	2,515 00
Crib sheeting in place, 36,100 feet B. M., at $40	1,444 00
Crib stone in place, 1,354 cubic yards, at $2	2,708 00
Riprap in place, 512 cubic yards, at 75 cents	384 00
	28,667 00

LOCK AND DAM NO. 12.

Located at Station 1102, at foot of "Half-mile Rapids," with height of wall 18 feet and lift of 10 feet, and is at the head of level of 0.5 mile. This lock will extend navigation to Shade's Creek, or northern limit of survey. Length of dam 300 feet, and height 10 feet.

Estimated cost.

Lock No. 12, same as Lock No. 11	$21,616 00
Crib framing in place, 8,890 linear feet, at 20 cents	1,778 00
Crib sheeting in place, 25,200 feet B. M., at $40	1,008 00
Crib stone in place, 941 cubic yards, at $2	1,882 00
Riprap in place, 355 cubic yards, at $1	355 00
	26,639 00

Channel excavations.

Sheet.	Station.	Locality.	Cubic yards.	Price.	Cost.
7	632–637	Big Shoals	1,000	$1 00	$1,000 00
7	651	do	56	1 00	56 00
7	652	do	112	1 00	112 00
7	653	do	266	1 00	266 00
7	657	do	536	1 00	536 00
7	678–680+50	Caffee Creek Shoals	1,112	1 00	1,112 00
7	717–719	Baily Reach Rapids	444	1 00	444 00
9	798–1002	Daly Creek Shoals	89	1 00	89 00
10	1088–1093	Long Island Rapids	2,223	1 00	2,223 00
11	1120–1122	Half-mile Rapids	222	1 00	222 00
11	1190–1194	Caffee Fish-trap Shoals	444	1 00	444 00
11	1200–1206	do	469	1 00	469 00
11	1225–1231	do	1,554	1 00	1,554 00
					8,527 00

Station 1201, Caffee Fish-trap Shoals, wing-dam, 100 feet, at $10 ..... $1,000 00
There are also some snags and overhanging trees to be removed.

Estimated cost:

193 snags, at $10 each 1,930 00
292 overhanging trees, at $5 each 1,460 00

3,390 00

RÉSUMÉ OF COST OF IMPROVEMENT OF UPPFR CAHABA RIVER, FROM CENTREVILLE TO NORTHERN BOUNDARY OF BIBB COUNTY.

Lock and dam No. 1	$38,296 00
Lock and dam No. 2	26,699 00
Lock and dam No. 3	31,699 00
Lock and dam No. 4	20,927 00
Lock and dam No. 5	23,527 00
Lock and dam No. 6	19,694 00
Lock and dam No. 7	30,710 00
Lock and dam No. 8	15,432 00
Lock and dam No. 9	28,094 00
Lock and dam No. 10	28,017 00
Lock and dam No. 11	28,667 00
Lock and dam No. 12	26,639 00
	318,401 00
Rock excavation, 8,527 cubic yards	8,527 00
Removal of snags and fallen trees	3,390 00
Wing-walls	1,000 00
	331,318 00
Engineering and contingencies, 15 per cent	49,697 00
	381,015 00
Estimate of survey of 1874:	
From Centreville to the mouth	194,598 00
	575,613 00

This estimate is on the basis of steamboat navigation to Centreville, a distance of 88 miles, and barge navigation to Shade's Creek, 23.67 miles farther, making a total distance of 111.67 miles.

I would respectfully recommend that the improvement be extended for the present no farther than the mouth of Cane Creek, Station, 1098. Lock No. 11 brings within reach the seam upon the Long Island Rapids and up Cane Creek, and at the head of the "Half-mile" Shoals just above 1098 commences the barren measures of the Cahaba field, and extend some distance through Shelby County. Nothing would, therefore, be gained unless the improvement is intended to be carried farther up at the present time.

By stopping at lock No. 11, or rather at Station 1098, mouth of Cane Creek, the estimated cost would be reduced $33,737, making total amount for the improvement recommended $541,886.

LINE OF LEVELS, CENTREVILLE TO CAHABA.

The examination and survey of the upper portion of the river was completed September 17, and I commenced in accordance with your letter of instructions, on September 25, a line of levels from the initial point at Centreville Ferry to the junction of the Cahaba River with the Alabama at Cahaba, a distance of 88 miles, in order to determine the total fall, slope of surface at the shoals, and to note the changes, if any, that had taken place since the survey of 1874.

Owing to the complete obliteration of all marks of that survey, the very considerable changes that had taken place in some portions of the river, and the neglect to give names of localities, shoals, and estates, islands and bars, in the notes, I found it impossible to accurately connect at all points with the transit base-line, depending upon the topographical features and general course of the river in the field notes.

The river for about 7 miles below Centreville has undergone no change of any note; its régime seems to be comparatively permanent. But below this point, about station 350, we enter upon that portion filled with large sand and gravel bars and islands, with caving banks, and channel oscillating from side to side, changing with nearly every freshet, the bars and islands diminishing and increasing continually. In the bend between Stations 354 and 370, on the Hill estate, a large bar has formed, extending one-third of the width of the river, and with a large dam of drift.

At 477 + 12, at the head of the "Hill Cut-off," the bar has increased down the river at least 400 feet, and extends out into the channel, with small islands in east chute.

At 1053 + 577, the bar has increased until the width at low-water does not exceed 55 feet. Between 1419 + 34 and 1435 + 07, the channel has shifted to opposite side, the bars are cut through, and islands formed with channels 30 feet and 15 feet, and filled with drift.

Between 1426 and 1513 + 41 (Potato Creek), large bars have formed in bends and at the mouth of the creek, the chute shown on map having been closed. At 2281 + 41, the bar has rapidly increased, with dams of logs and drift, through which we had to cut a passage for the boats. The last change of any consequence is near station 2397, just above Fikes Ferry, where an island of considerable extent has formed. The distance that the sand and gravel bars and islands extend is about 39 miles. The remaining portion. from 2410 to Cahaba, is again comparatively permanent, with no alterations of any note.

The fall from Centreville to the mouth is 127.4 feet, and from Shades Creek, the north boundary of Bibb, to Centreville is 121.4 feet, making the total fall in a distance of 111.67 miles 248.8 feet.

The following is a table of the slope of surface at and between the more important shoals.

Table of surface slope of the Cahaba River, Centreville to Cahaba.

Locality.	Fall.	Distance in miles.	Rate per mile.	Remarks.
Centreville Ferry	.....	.....	.....	0 of 1880 = 26 of 1874.
North end of Mayberry Island	.005	.57	.009	
Moren's Gin	.747	.379	1.97	
Head of Shoals No. 2	.839	3.08	.272	
Lee Ford	1.005	1.07	.94	
Head of Hill's Cut-off	2.401	3.315	.74	
Foot of Hill's Cut-off	3.527	1.77	2.00	
Head of Shoals No. 5	.602	1.027	.58	
Foot of Shoals No. 5	.584	.0065	9.61	
Head of New Cut-off	.984	.647	1.52	Distance through cut-off is only 200 feet.
Through New Cut-off	.344	.048	.72	
Foot of Shoals No. 9	6.895	5.58	1.28	Bibb and Perry line near 872+16.
Head of Shoals No. 10	.189	1.455	.13	
Foot of Shoals No. 10	.803	.112	7.17	
Head of cluster of islands	.846	1.900	.44	
Taylor's Creek	1.099	.348	3.26	
Station 1290+87	2.364	2.18	1.09	
Station 1321+20	1.294	.57	2.27	
Lower end of island above Jericho	.553	.945	.585	
Lower end of sand-bar	1.153	1.51	.76	
Potato Creek Shoals No. 15	1.226	1.008	1.21	
Foot of Shoals No. 15	3.501	.43	8.14	
Head of Shoals No. 16	1.642	.65	2.53	
Head of Shoals No. 18	1.431	1.23	1.16	
Station 1696	.678	1.06	.64	
Head of Block's Cut-off	1.152	.47	2.45	
Foot of Block's Cut-off	.854	.19	4.39	
Head of Shoals No. 19	2.620	1.36	1.92	
Foot of Shoals No. 20	2.943	.80	.37	
Head of Shoals No. 24	2.028	2.91	.70	
Upper end of island	9.193	.52	.42	Above Burras Ferry.

Table of surface slope of the Cahaba River, Centreville to Cahaba.—Continued.

Locality.	Fall.	Distance in miles.	Rate per mile.	Remarks.
Foot of Shoals No. 29	7.296	2.75	2.65	
Head of Shoals No. 34	4.769	2.44	1.95	
Head of Shoals No. 35	1.367	.37	3.70	
Waters Creek	3.339	1.93	2.73	
Fike s Ferry	1.677	.23	7.28	
Oak Mulgre Creek	24.453	16.63	1.42	Perry and Dallas line, near 3281.
Head of Log Shoals	6.170	5.17	1.19	
Foot of Log Shoals	6.392	4.02	1.59	
Upper end of island	1.792	2.595	.68	"Tally's Defeat."
Lower end of island	1.254	.134	9.40	
Alabama River	22.413	13.25	1.69	
	127.404	86.67	.....	

The party reached Cahaba October 8, and was there disbanded.

Respectfully,

C. B. PERCY,
Assistant Engineer.

Maj. A. N. DAMRELL,
Captain Corps of Engineers, U. S. A.

APPENDIX L.

INSPECTION OF THE IMPROVEMENT AT THE SOUTH PASS OF THE MISSISSIPPI RIVER.

REPORT OF CAPTAIN WILLIAM H. HEUER, CORPS OF ENGINEERS, INSPECTING OFFICER, FOR THE FISCAL YEAR ENDING JUNE 30, 1881.

OFFICE UNITED STATES ENGINEER,
New Orleans, La., July 18, 1881.

GENERAL: I have the honor to transmit the annual report of the progress of the work on the improvement of the South Pass of the Missippi River.

The body of the report is made by Mr. C. Donovan, the assistant engineer in local charge of the work of examinations and surveys at the pass.

An examination of the report and chart shows that there was, during the entire year, through the jetties a channel 30 feet deep, having a least width of 20 feet, and that the 26 feet deep channel had a least width of 200 feet. The least present width of this channel is 230 feet.

Outside of and beyond the jetties the least width of the 30 feet deep channel was 60 feet, while the 26 feet deep channel had a least width of 210 feet, except for a very few days during the year, when this channel was somewhat narrower.

Above the jetties, and through the pass itself, the least channel depth is now 27 feet, and its least width is 160 feet. A channel 26 feet deep was maintained through the pass during the year, except, for a few days, a short distance below its head, when the depth, for a short distance, was slightly less.

At present there is a channel from the main river into the Gulf whose least depth is 27 feet and least width is 160 feet.

The steamer Teutonia, drawing 25 feet of water, passed through the South Pass, February 4, 1881, without grounding.

The bed of the pass has in some places scoured and in others filled. During the year the fill has exceeded the scour by about one-tenth of a foot only, measured vertically. From June, 1875, to October, 1880, in a little more than five years, the average depth of fill in the pass was 2.5 feet. As a rule the filling has occurred most where the pass was widest, and rarely has any filling occurred in the channel where the depth was less than 27 feet. The profile-chart shows much of the fill to have lodged in the deeper pockets of the pass.

The most interesting and important facts developed in the examinations and surveys made during the year relate to the changes that have occurred in the fan-shaped area in the Gulf of Mexico beyond the outer ends of the jetties and extending out to 100 feet depth of water.

From June 30, 1879, to June 30, 1880, the separate surveys of this area, compared with each other, showed an average scour during the year of twelve one-hundredths of one foot, an amount so small as to be practically nothing; but this year, June, 1880, to June, 1881, instead of a scour there has been an average deposit or fill over this large area ($1\frac{1}{4}$ square miles) of 2.38 feet.

The localities within this area within which changes have occurred, whether scour or fill, as well as the amount of the changes, are shown on the shaded plans on page 46 of Mr. Donovan's report. Attention is especially invited to that part of the report headed "Surveys beyond the ends of the jetties."

The report contains details of cribs, repairs, and other work done on the jetties, and of the wing-dams built below the head of the pass, by Captain Eads, to contract the water-way and produce a scour. My acknowledgments are due Messrs. Donovan and Raymond, assistant engineers at the jetties, for valuable services well rendered.

Respectfully submitted.

W. H. HEUER,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. C. DONOVAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., July 15, 1881.

SIR: I have the honor to present herein a report of the condition of the works constructed by Mr. James B. Eads, for the improvement of South Pass of the Mississipp River, on June 30, 1881; and also giving the amount and character of the work done during the fiscal year ending with the same date. The report also contains the results of examinations and surveys made during the year to ascertain the effects of the works upon the channel throughout South Pass, and also over a certain area at the Head of the Passes and in the Gulf of Mexico.

The following charts and plates of diagrams accompany the report:

No. 1. Chart of jetty channel to station 50.

No. 2. Chart, continuation of No. 1; showing jetty channel from station 50 to end of jetties.

No. 3. Chart of a part of the Gulf of Mexico.

No. 4. Chart of South Pass, from South Pass light-house to Bayou Grande.

No. 5. Chart of South Pass, from Bayou Grande to the Head of Passes.

No. 6. Chart of the Head of Passes.

No. 7. Chart plan, comparative profiles and cross-sections of South Pass, from Head of Passes to the end of the jetties.

No. 8. Chart showing the relative position of curves of depth in the Gulf of Mexico, comparing those of 1876 with those of 1881.

No. 9. Chart of various sections, plans, water-level curves, &c.

Plate I. Diagrams showing changes in the Gulf.

Plate II. Diagrams showing changes in the Gulf from 1876 to 1881.

HEAD OF PASSES.

No work has been done at this point since July, 1879, and with slight exceptions, herein noted, the works remain in substantially the same condition as when last reported upon (June 30, 1880).

The breaks in Upper Dam have not increased in width, but remain as last reported, viz, 130 and 620 feet. The depth of water through the one nearest the junction of Upper Dam and east T-head extension averages 17 feet, while that through the longer break has increased 5 feet during the year, and now averages 23 feet. The western 430 feet of this dam is still in good condition and above average flood-tide; the other portions not carried away are about 15 feet below this plane. On Chart No. 6, the portions of this dam which are not in place are indicated by a broken line.

There is a break about 50 feet wide in the east T-head extension, at its junction with

Dam No. 2, through which there is a depth of from 7 to 10 feet of water; this does not seem to be of much consequence as yet, since the water between Dam No. 2 and Upper Dam is but from 2 to 5 feet in depth; and over a large portion of the area between these dams marsh grass is growing, and prevents any considerable current through this break. There is another break in the east T-head extension, 500 feet below its junction with Upper Dam, which is 60 feet wide, and through which there is a depth of 27 feet. Through this break there is a strong current, which is scouring a channel from the T-head into the main channel.

Mattress sills across Southwest and Northeast Passes.—The sill across Southwest Pass indicates an average settlement of about 2⅓ feet during the year, being greatest 500 feet from the west shore. The upper surface seems to be very irregular, indicating that either some of the mattresses have been washed out or have settled more in some places than in others; it is impossible; however, to tell which is the case, for there are some mattresses in place throughout the entire length of the sill.

The sill across Northeast Pass has settled from 1 to 3½ feet, being greatest on the west end and least on the east end, and a comparison of the soundings this year, with those taken in October, 1877, shows this settlement to have taken place during the past year.

IN SOUTH PASS ITSELF.

During the month of March, a shoaling occurred in the pass, at a locality about 1⅝ miles below the Head of Passes light-house, which was occasioned to some extent by a scouring which was found to be going on at the head of the pass; this shoaling rendered the channel at this point less than 26 feet in depth (see your certificate of May 9, 1881, herewith appended), and accordingly the dredge-boat G. W. R. Bayley commenced work here, and after working about nine days with but little effect, the work of dredging was discontinued after April 6, and the work of building wing-dams to contract the water-way and deepen the channel at this point was commenced April 28, and concluded May 7.

These dams project from the east shore of the pass, at right angles to the same, and are built by driving piles from 5 to 10 feet apart, against which is placed a lattice-work, constructed of 2 by 6 inch scantlings placed at right angles to each other, and 2 feet apart from center to center, thus leaving openings 18 inches square; at every alternate point of contact these scantlings are bolted together with three-eighths-inch carriage-bolts, 4½ inches long. The lattice-work is built in sections of from 20 to 40 feet in length, and varying in height according to the depth of water at the locality where they are to be placed; it projects from 2 to 5 feet above the surface of the water when first placed in position. The lattice is held in position against the piles by the force of the current against it, not being fastened to the piles, in order that it may sink into the bottom in case a scouring takes place underneath it. A timber, generally 6 by 8 inches, connects the piles a few feet above the surface of the water, and is bolted to them to strengthen and stiffen the dam. For the uppermost dam (No. 1, see Chart No. 5) seven piles were driven 16 feet below and parallel to it, and 15 feet apart, against which, and on the bottom, rests a pile horizontally, to which is fastened one end of a pile, the other end of which is fastened to a pile in the dam, and serves as a brace; there are seven of these braces in Dam No. 1, but this is the only dam braced in this way. The outer one of these seven piles has a brace extending from near the top of it to near the top of the main brace.

The locations of these dams are shown on Chart No. 5. They are numbered 1, 2, and 3, and are, respectively, 200, 180, and 180 feet long and 650 feet apart. On the same chart is also shown, in elevation, the shore section of Dam No. 1 and a cross-section near the river end.

In the construction of these dams, 67 piles, 10,277 feet B. M. scantling, and 1,155 bolts were used.

Besides the above-mentioned dams, another was constructed and designed to be placed 420 feet above No. 1. This consisted of a model barge 165 feet long, upon which was built a lattice-work (according to the plan above described), which was 18 feet high at one end and 12 feet at the other. This was built along the center line of the barge and braced to the deck by timbers 15 feet apart. The structure was towed to position and placed against piles which had been driven to guide it in sinking and afterwards to hold it in place. Openings were made in it to admit the water, and 82 cubic yards of dirt ballast was added to aid in sinking.

The anchorage, which held the barge so that the whole force would not be against the piles, proved too weak in so strong a current and gave way. The river end of the barge swung shoreward, breaking the guide-piles off, and the structure landed in a broken condition in a position as shown on the chart above referred to. In this position and condition the structure had but little effect. The material used for this dam, besides the barge, was 7 piles, 2,460 feet B. M. scantling, and 290 bolts.

The old dam near the head of Bayou Grande, which projects from the west shore in a direction across the pass, has been extended by the addition of 95 feet in length of

lattice-dam the same as above described. With this addition the dam is 285 feet in length. The old portion, though much deteriorated, is to some extent effectual, since the water along it is shoal and the drift-wood lodged against it obstructs to some extent the passage of water over the dam. The addition to this dam was for the purpose of diminishing the cross-section at this point, in order to decrease the shoaling which is going on here.

For the addition to this dam 10 piles, 2,688 feet B. M. scantling, and 350 bolts were used.

Its location is shown on Chart No. 5.

DAM ACROSS BAYOU GRANDE.

No work has been done on this dam, which is located nearly three-fourths of a mile below the head of the bayou, since April, 1878. The piles and other wood-work above the surface of the water are becoming badly decayed; otherwise the dam remains in fair condition. The upper surface of the top mattress is about 3 feet below average flood-tide. The depth of water through the bayou above the dam is 4½ feet, which is the same as it was one year ago.

AT THE MOUTH OF SOUTH PASS.

The wind and rain storm in February, and its effect upon the jetties.—I give in this connection an account of the storm which occurred here early in February, since the necessity for some of the work hereafter described was caused by the effect of this storm, and the subsidence of the concrete blocks, determined after the storm was over, was found to be greatest at localities where the parapet-wall was most disturbed.

At 8 p. m. on the night of February 4, the wind was blowing from south-southeast, with a velocity of 13 miles per hour. It increased gradually in velocity, varying but slightly in direction, and at 8 a m. on the 5th instant it had attained a velocity of 25 miles per hour, which it maintained, with but slight variations, until 5 a. m. on the 6th, at which time it had increased to 29 miles per hour; it continued increasing until noon, when the maximum velocity of 35 miles per hour was attained. This velocity was maintained until about 4 p. m., when the wind changed to a northerly direction and decreased to 4 miles per hour at 6 p. m.; it continued in this direction but a few hours, when it again changed to southeast. From this time until about noon on the 9th instant the velocity was variable, at times reaching 25 miles per hour, but only for short intervals. The rain, which commenced about noon on the 5th, continued almost unceasingly until about noon on the 8th, when the weather cleared, but the wind continued with a velocity of more than 10 miles per hour up to noon on the 9th instant. This storm was the most violent of any which has occurred here since the works were commenced.

The rubble parapet wall on the east jetty was slightly damaged in places, and occasional foundation blocks in both jetties were found to have settled considerably. The damage to the parapet wall is confined to that portion between Stations 81 and 97, but over this reach there is a space of 335 feet where no parapet had ever been built, leaving, therefore, 1,215 feet of wall which was damaged. Over this distance there are sixteen localities where the wall has been destroyed, the lengths of the portions destroyed varying from 1 to 20 feet; the total length of wall destroyed being 97 feet. Aside from the localities where the wall was destroyed, there were fifteen other places where it was simply cracked. These cracks occur over the ends of the foundation blocks in every case, and are caused by the unequal settlement of the same. There seems to be no unusual settlement where the wall is intact. The only damage sustained by the west jetty was the settlement of one block (73) at station 113, the subsidence amounting to 1.75 feet.

EAST JETTY.

The work at the mouth of the pass during the year has been almost exclusively confined to this jetty. The following is a classification of the work on this structure:

1. Building and sinking of crib-work.
2. Building rubble wall on concrete blocks and on spur-cribs.
3. Plastering concrete parapet.
4. Distributing material along the concrete blocks.

1. *Building and sinking of crib-work.*—This work, as stated in a previous report, is for the purpose of strengthening and protecting the sea end of the jetties, and they will also serve as a foundation in the event of extending the jetties; the spur-cribs built during the year have been placed along the sea side of this jetty to serve in protecting the concrete wall by breaking the swells which race along it with undermining effect; most of these were built and placed in position after the February storm.

The construction of these cribs is fully described and explained by drawings in my report of last year. (See Appendix L, Report of the Chief of Engineers United States Army, pages 1124 and 1125.) Forty cribs have been built and placed in position during the year. Of this number, two have been placed upon the old wing-dam at the end of the jetty, to build up that structure so as to divert the current from the end of this jetty and confine it more directly between the jetties; three have been placed near to and directly in advance of the jetty; two east of a line which is the prolongation of this jetty; two on base-line reef at its junction with the east jetty, to prevent this reef from moving further landward; the remaining thirty-one have been placed along the sea side of the jetty. The *spur-cribs* are built to conform with the bottom at the locality where they are to be placed, so that when in place their upper surface will be horizontal.

On Chart No. 9 is given a plan showing the total number and position of cribs in place, and a cross-section which will explain the construction of the spur-cribs.

The following table gives the dimensions, character, location, &c., of each crib placed during the year, and the total amount of material in all that have been built since this work was commenced. The number of each crib corresponding to that given in the table will be found on the plan above referred to.

Table giving dimensions, character, and location of cribs used during the fiscal year, and also the total amount of this work used in all constructions.

Number of crib.	Month when sunk.	Description.	Dimensions.	Number of feet palmetto.	Number of feet cypress.	Number of feet pine.	Number of feet plank.	Location.
				20,112	7,403	9,192	2,800	Totals as reported for the year ending June 30, 1880.
	1880.		*Feet.*					
40	August	Palmetto	64 × 17 × 11	5,130	704	.....	.....	Station 117 + 25, river side, east jetty.
41	....do	.....do	35 × 18 × 10 and 14*	2,478	560	.....	.....	Do
42	October	.....do	40 × 21 × 9.5	2,784	680	.....	.....	Across end of east jetty.
43	November	.....do	44.4 × 19 × 11	3,420	731	.....	.....	Do
44	December	.....do	40.5 × 19.7 × 12	3,770	769	.....	.....	Do
	1881.							
45	March	.....do	39 × 19.5 × 12 and 14	4,010	936	.....	.....	Station 118 + 75, on a line which is the prolongation of east jetty.
46	February	.....do	64.5 × 20.5 × 13 and 8.5	5,748	.....	1,179	.....	Station 118, eastward of a line which is the prolongation of east jetty.
49	April	Spur palmetto	19.5 × 12 × 4 and 2	135	240	.....	.....	Station 89 + 75, sea side, east jetty.
50	....do	.....do	19.5 × 12 × 4 and 2	135	240	.....	.....	Station 90 + 85, sea side, east jetty.
51	....do	.....do	17 × 10.5 × 5 and 2	198	.....	.....	188	Station 92 + 24, sea side, east jetty.
52	....do	.....do	15.4 × 9.5 × 5 and 2	204	.....	.....	148	Station 93 + 24, sea side, east jetty.
53	....do	.....do	16 × 10.4 × 6 and 2	196	.....	.....	152	Station 94 + 40, sea side, east jetty.
54	....do	.....do	16 × 11 × 5 and 2	203	.....	.....	134	Station 95 + 55, sea side, east jetty.
55	....do	.....do	16 × 9.5 × 5 and 2	194	.....	.....	132	Station 96 + 54, sea side, east jetty.
56	....do	.....do	16 × 9.5 × 5 and 2	194	.....	.....	132	Station 88 + 76, sea side, east jetty.
57	....do	.....do	16 × 9 × 5 and 2	190	.....	.....	132	Station 87 + 62, sea side, east jetty.
58	....do	.....do	15 × 11 × 6 and 2	199	.....	.....	123	Station 86 + 82, sea side, east jetty.
59	....do	.....do	16 × 11 × 6 and 2	203	.....	.....	130	Station 85 + 65, sea side, east jetty.
60	....do	.....do	16 × 10 × 5 and 2	195	.....	.....	120	Station 84 + 23, sea side, east jetty.
61	....do	.....do	16 × 11 × 5.5 and 2	200	.....	.....	125	Station 83 + 23, sea side, east jetty.
62	May	.....do	16 × 11 × 5 and 2	198	.....	.....	125	Station 82 + 20, sea side, east jetty.
63	....do	.....do	17 × 11 × 6 and 2	205	.....	.....	130	Station 81 + 19, sea side, east jetty.
64	....do	.....do	17 × 11 × 5 and 2	200	.....	.....	125	Station 80 + 13, sea side, east jetty.
65	....do	.....do	17 × 10 × 5 and 2	200	.....	.....	125	Station 79 + 16, sea side, east jetty.
66	....do	.....do	17 × 10 × 5 and 2	200	.....	.....	125	Station 78 + 21, sea side, east jetty.
67	....do	.....do	17 × 11 × 5 and 2	200	.....	.....	125	Station 77 + 8, sea side, east jetty.
68	....do	.....do	16 × 11 × 4 and 1	136	.....	.....	.....	Station 76 + 13, sea side, east jetty.
69	....do	.....do	16 × 11 × 4 and 1	136	.....	.....	.....	Station 75 + 12, sea side, east jetty.
70	....do	.....do	16 × 11 × 4 and 1	136	.....	.....	.....	Station 74 + 15, sea side, east jetty.
71	....do	.....do	16 × 11 × 4 and 1	136	.....	.....	.....	Station 73 + 15, sea side, east jetty.
72	....do	.....do	16 × 11 × 4 and 1	136	.....	.....	.....	Station 72 + 35, sea side, east jetty.

73	....do	.....do	16 × 11 × 4 and 1	136				Station 71 + 23, sea side, east jetty.
74	June	.....do	16 × 10 × 5 and 2	198				Station 97 + 56, sea side, east jetty.
75	...do	.....do	16 × 10 × 5 and 2	198				Station 98 + 51, sea side, east jetty.
76	....do	.....do	16 × 10 × 5 and 2	198				Station 99 + 41, sea side, east jetty.
77	....do	.....do	16 × 10 × 5 and 2	198				Station 100 + 42, sea side, east jetty.
78	...do	.....do	16 × 10 × 5 and 2	198				Station 101 + 37, sea side, east jetty.
79	....do	.....do	16 × 10 × 5 and 2	198				Station 91 + 62, sea side, east jetty.
80	....do	Palmetto	68 × 16 × 4	1, 456				Sea side of base-line reef at its junction with east jetty.
81	....do	.....do	76 × 16 × 3½	1, 552				
				15, 800				Total up to June 30, 1879.
				71, 913	12, 262	10, 371	5, 071	Total up to June 30, 1881.
				36, 001	4, 860	1, 179	2, 271	Total during the year ending June 30, 1881.

* Where cribs are not uniform in height, this dimension at each end is given.

In sinking these forty cribs, 1,692 cubic yards of stone, 21 cubic yards of macadam, and 39 cubic yards of gravel were used.

The stone used during the year was discharged as ballast from vessels, and some was taken off the jetty below East Point, where it is no longer needed.

2. *Building rubble wall on concrete blocks and on spur-cribs.*—During the year the rubble parapet has been built from Station 94 + 50 to Station 90 + 50, a distance of 400 feet; this wall is 3 feet wide and varies in height from 2.2 to 2.6 feet. From Station 90 + 50 to Station 89 + 40, a distance of 110 feet, this wall has been partially built, and requires one or two courses of stone throughout this length to complete it. Two hundred and twenty feet (from 87 + 20 to 89 + 40) remain to be built and 110 feet to be completed in order to finish the parapet over the foundation blocks in place. Portions of this wall which were broken during the February storm, amounting in total to 97 feet in length, have been repaired or rebuilt.

The masonry which terminated at Station 65 + 15, a year ago, has been extended up stream to Station 63 + 20, a distance of 195 feet; this portion is built entirely of rubble-stone laid in cement mortar. The foundation rests upon the top of the mattresses, which were previously covered with 41 cubic yards of stone; it is 4 feet wide and 2 feet high, except the upper 47 feet, which is 2½ feet wide and 2.2 feet high; the parapet surmounting this is from 2 to 2½ feet wide and from 2 to 2.2 feet high. This portion was built in consequence of the movement landward of base line reef, which has its junction with the jetty 300 feet further up stream than it was a year ago; the reef has receded about 200 feet and increased in area.

The rubble parapet for 100 feet in length below Station 65 + 15 has been repaired; it had become canted in consequence of the settlement of the foundation concrete blocks which rested upon a sand foundation that had become partially washed out.

The thirty-one spur-cribs have been capped by blocks of masonry composed of rubble-stone laid in cement mortar; these blocks average 13.2 feet long, 4 feet wide, and 3.8 feet high, their upper surface being level with the upper surface of the parapet on the jetty; they are built in contact with the foundation blocks on the jetty, but are separated from the parapet about 6 inches (see section on Chart No. 9). One block measuring 14.3 by 4.6 by 4 feet has been built on the sea side of the jetty at Station 63 + 20; it rests upon the top mattress of the jetty and partly on the sand reef; this is intended to break the force of the sea against the reef and prevent its further recession.

Number of linear feet of masonry built	1,251
Number of cubic yards of masonry	468

The amount and character of masonry in place June 30, 1881, is represented on Chart No. 4, and explained in a note thereon.

The following table gives the elevation of the top of the parapet wall above average flood-tide according to levels taken at various dates at points 100 feet apart; it also gives the subsidence during the year and since the wall was built. Levels are taken every month, but the variation is so slight that the results for every three months as given will suffice to show the changes.

Table giving elevation referred to average flood-tide, and total subsidence of parapet wall on east jetty.

Location.	Date when built.	Elevation in feet.					Total subsidence.		Remarks.
		1880.			1881.				
		June 24.	September 15.	December 23.	March 5.	June 15.	Since June, 1880.	Since wall was built.	
	1881.								
63 + 20	June	.....	.....	.....	.....	4.35	.....	.....	Parapet from Station 63 + 20 to Station 87 + 15 and from 90 + 50 to 101 + 79 is built of rubble-stone.
64 + 25	May	.....	.....	.....	.....	4.21	.....	.....	
	1880.								
65 + 15	April	4.47	4.33	4.31	4.26	4.26	0.21	0.35	
66 + 15	....do	4.28	4.49	4.45	4.39	4.40	0.09	0.27	
67 + 15	....do	4.53	4.39	4.34	4.29	4.30	0.23	0.28	
68 + 15	....do	4.61	4.37	4.34	4.29	4.27	0.44	0.50	
69 + 15	....do	4.56	4.46	4.43	4.36	4.36	0.20	0.24	
70 + 15	....do	4.53	4.40	4.40	4.31	4.34	0.19	0.26	
71 + 15	....do	4.66	4.41	4.40	4.33	4.30	0.36	0.42	

Table giving elevation referred to average flood-tide, &c.—Continued.

Location.	Date when built.	Elevation in feet.					Total subsidence.		Remarks.
		1880.			1881.		Since June, 1880.	Since wall was built.	
		June 24.	September 15.	December 23.	March 5.	June 15.			
	1880.								
72 + 15	April	4.55	4.40	4.42	4.35	4.34	0.21	0.27	
73 + 15	May	4.59	4.40	4.39	4.34	4.33	0.26	0.31	
74 + 15	....do	4.63	4.65	4.63	4.58	4.55	0.08	0.08	
75 + 15	....do	4.59	4.40	4.40	4.33	4.33	0.26	0.28	
76 + 15	....do	4.65	4.45	4.42	4.32	4.31	0.34	0.36	
77 + 15	....do	4.69	4.57	4.57	4.51	4.47	0.22	0.23	
78 + 15	....do	4.65	4.38	4.38	4.32	4.30	0.35	0.35	
79 + 15	....do	4.70	4.43	4.45	4.38	4.35	0.35	0.35	
80 + 15	....do	4.47	4.21	4.21	4.09	4.07	0.40	0.42	
81 + 15	April	4.38	3.96	3.99	3.87	3.87	0.51	0.53	
82 + 15	....do	4.55	4.28	4.30	4.21	4.20	0.35	0.36	
83 + 15	....do	4.49	4.33	4.37	4.25	4.20	0.29	0.33	
84 + 15	....do	4.55	4.28	4.27	4.03	4.00	0.55	0.59	
85 + 15	....do	4.38	4.25	4.28	4.13	4.12	0.26	0.51	
86 + 15	....do	4.42	4.34	4.26	3.89	3.86	0.56	0.74	
87 + 15	June	4.59	4.37	4.36	4.03	3.99	0.60	0.60	
91	July	(*)	4.37	4.37	4.03	3.97	.....	0.52	
92	....do	(*)	4.46	4.40	3.93	3.87	.....	0.83	
93	....do	(*)	4.64	4.45	4.19	4.05	.....	0.72	
94	....do	(*)	4.51	4.50	4.38	4.34	.....	0.32	
95	....do	(*)	4.49	4.47	4.15	4.12	.....	0.50	
96	June	4.60	4.28	4.29	4.14	3.98	0.62	0.62	
97	March	4.53	4.18	4.19	4.11	4.04	0.49	0.49	
98	....do	4.44	4.09	4 10	3.95	3.93	0.51	0.58	
99	February	4.20	3.77	3.74	3.65	3.58	0.62	0.77	
100	....do	4.51	4.13	4.11	4.04	3.97	0.54	0.57	
101	January	4.57	4.18	4.15	4.07	4.01	0.56	0.63	
101 + 79	....do	4.50	4.17	4.18	4.12	4.03	0.47	0.48	
103	June	5.24	5.16	5.13	5.04	4.96	0.28	0.29	Parapet from Station 102 + 15 to Station 116 + 33 is built of concrete.
104	....do	5.19	4.87	4.84	4.81	4.75	0.44	0.44	
105	....do	5.38	5.08	5.04	4.97	4.90	0.48	0.48	
106	March	5.40	5.13	5.10	5.04	4.96	0.44	0.44	
107	....do	5.43	5.19	5.11	4.98	4.92	0.51	0.51	
108	....do	5.49	5.03	5.02	4.94	4.85	0.64	0.64	
109	....do	5.36	4.91	4.92	4.85	4.74	0.62	0.62	
110	April	5.56	5.05	5.00	4.90	4.81	0.75	0.75	
111	....do	5.76	5.27	5.21	5.12	5.03	0.73	0.73	
112	....do	5.91	5.46	5.42	5.33	5.23	0.68	0.68	
113	....do	6.15	5.70	5.66	5.68	5.40	0.75	0.75	
114	....do	6.22	5.77	6.00	5.88	5.79	0.73	0.73	Parapet at Station 114 was raised 0.3 by plastering in September, 1880.
115	....do	6.63	6.45	6.39	6.31	6.18	0.45	0.45	
115 + 90	June	6.81	6.62	6.52	6.47	6.31	0.50	0.50	
116 + 60	....do	3.58	3.17	3.07	2.99	2.82	0.76	0.76	From Station 116 + 33 to 117 + 73, distance 140 feet, there is no parapet. Levels were taken on foundation blocks.
117 + 08	....do	3.58	3.19	3.06	2.96	2.74	0.84	0.84	
117 + 52	....do	3.10	2.90	2.62	2.33	2.09	1.01	1.01	
Average subsidence							0.46	0.51	
Greatest subsidence (at Station 117 + 52							1.01	1.01	

* First levels taken in August, 1880.

NOTE.—Between Stations 87 +15 and 90 + 50, a distance of 335 feet, there was no parapet wall built June 15, when the last levels were taken. The sixteen concrete blocks occupying this space, *i. e.*, the foundation blocks, show an average subsidence since they were built, in December, 1879, of 1.1 feet; the greatest subsidence of any one block being 1.43 feet.

3. *Plastering concrete parapet.*—The concrete parapet from Station 102 + 8 to Station 107 + 75, and from Station 113 + 75 to 116 + 33, a total distance of 825 feet, has been plastered or pointed, so that it presents a smooth and even appearance, leaving this portion in a perfectly finished condition.

4. *Distributing material along the concrete blocks.*—During the year, 33 cubic yards of gravel were placed on the jetty extending over a distance of 65 feet below Station 63, and 22 cubic yards between Stations 60 and 63. Between Stations 63 and 65, 62 cubic yards of rubble-stone, 65 of marl, and 10 of gravel were used to raise the surface of the jetty at this locality. Sixty-five cubic yards of gravel were placed on the river side of

the concrete work between Stations 70 and 79, and 96 cubic yards of rubble-stone, 77 of macadam, and 32 of marl were placed on the sea side at the same locality. From Station 95 to 101, 121 cubic yards of gravel and 101 of marl were placed on the river side; on the same side from Stations 102 to 110, 143 cubic yards of macadam and 84 cubic yards of gravel were placed. At Station 105, 59 cubic yards of rock were placed on the river side, 19 cubic yards of macadam at Station 110, 5 cubic yards of gravel at Station 112, 95 cubic yards of marl between Stations 90 and 95, and 76 cubic yards of marl between Stations 101 and 105, all on the river side of the concrete blocks.

The material placed along the concrete blocks is for the purpose of preventing or checking the leakage of water under the blocks.

Between cribs Nos. 38 and 39 at the end of the jetty, 22 cubic yards of macadam were placed; 26 cords of willows weighted with 11 cubic yards of stone were placed between crib 40 and the concrete work on the jetty to fill a void at this place.

WEST JETTY.

No work has been done upon this jetty during the year; it remains in good condition, only a slight settlement of the concrete blocks having occurred.

During the month of August 24 cords of willows and 30 cubic yards of stone were placed on "Pelican Reef" near its junction with the jetty, to obstruct a channel which was scouring on the sea side of the jetty by the water which escaped over it at high-tide. This work, together with that (of the same character) which was done last year, has been effectual, and the reef has formed seaward of where this material was placed. The reef has changed in form and greatly increased in area during the year, but maintains about the same position as it did a year ago. Its present location is shown on Chart No. 2.

The following table gives in detail information regarding the settlement of the concrete blocks on the west jetty.

Tables showing elevation of concrete blocks, at various dates, above the plane of average flood-tide, and the total subsidence of each block from the date of the first observation and also during the year.

WEST JETTY, BELOW STATION 101+25.

Number of block.	Date when laid.	Location of block.	Elevation in feet and tenths.					Total subsidence.	
			1880.			1881.			
			June 23.	September 15.	December 13.	March 25.	June 15.	Since June 23, 1880.	Since blocks were laid.
	1879.								
1	Jan. 31	Station 101+25	2.33	2.18	2.08	2.04	1.99	0.34	0.44
2	Jan. 30		2.28	2.12	2.03	1.98	1.91	0.37	0.48
3	Jan. 30		2.27	2.10	2.00	1.94	1.87	0.40	0.59
4	Jan. 29		2.44	2.27	2.16	2.10	2.04	0.40	0.56
5	Jan. 29	Station 102	2.66	2.51	2.38	2.32	2.26	0.40	0.60
6	Jan. 28		.....	.....	.....	...	.....	(*)	(*)
7	Jan. 21		1.72	1.57	1.47	1.45	1.41	0.31	0.78
8	Jan. 22		1.54	1.44	1.29	1.28	1.28	0.26	0.78
9	Jan. 23		1.44	1.35	1.24	1.23	1.22	0.22	0.79
10	Jan. 23		1.47	1.38	1.29	1.27	1.22	0.25	0.83
11	Jan. 24		1.57	1.48	1.39	1.17	1.01	0.56	1.17
12	Jan. 25	Station 103	1.78	1.68	1.60	1.19	1.16	0.62	1.21
13	Jan. 27		2.10	2.02	1.92	1.88	1.85	0.25	0.79
14	Jan. 27		2.11	2.03	1.94	1.91	1.88	0.23	0.80
15	Jan. 31		2.30	2.22	2.13	2.11	2.07	0.23	0.78
16	Feb. 1		2.23	2.14	2.05	1.79	1.74	0.49	0.91
17	Mar. 21		2.65	2.54	2.45	2.26	2.22	0.43	0.63
18	Mar. 21		2.62	2.54	2.44	2.42	2.37	0.25	0.47
19	Mar. 21	Station 104	2.55	2 46	2.37	2.35	2.31	0.24	0.56
20	Mar. 21		2.53	2.44	2.36	2.33	2.28	0.25	0.61
21	Mar. 21		2.59	2.51	2.43	2.40	2.33	0.26	0.69
22	Mar. 24		2 50	2.41	2.32	2.31	2.25	0.25	0.61
23	Mar. 24		2.42	2.32	2.22	2.19	2.14	0.28	0.66
24	Mar. 24	Station 105	2.35	2.26	2.15	2.14	2.08	0.27	0.71
25	Mar. 24		2.28	2.19	2.09	2.07	2.02	0.26	0.75
26	Mar. 24		2.16	2.07	1.97	1.94	1.89	0.27	0.76
27	Mar. 25		2.22	2.13	2.03	2.01	1.96	0.26	0.73
28	Mar. 25		2.35	2.26	2.15	2.12	2.09	0.26	0.72
29	Mar. 25		2.48	2.39	2.28	2.25	2.21	0.27	0.72
30	Mar. 25		2.58	2.49	2.38	2.35	2.32	0.26	0.65

Table showing elevation of concrete blocks, at various dates, &c.—Continued.

WEST JETTY, BELOW STATION 101+25.

Number of block.	Date when laid.	Location of block.	Elevation in feet and tenths.					Total subsidence.	
			1880.			1881.			
			June 22.	September 15.	December 13.	March 25.	June 15.	Since June 23, 1880.	Since blocks were laid.
	1879.								
31	Mar. 26	Station 106	2.65	2.55	2.44	2.42	2.38	0.27	0.74
32	Mar. 26		2.62	2.52	2.40	2.37	2.34	0.28	0.78
33	Mar. 26		2.61	2.50	2.39	2.36	2.32	0.29	0.82
34	Mar. 26		2.72	2.60	2.52	2.48	2.43	0.29	0.81
35	Mar. 26		2.73	2.58	2.48	2.45	2.42	0.31	0.80
36	Mar. 27		2.67	2.54	2.44	2.40	2.36	0.31	0.87
37	Mar. 27	Station 107	2.81	2.69	2.58	2.54	2.49	0.32	0.82
38	Mar. 27		2.79	2.67	2.59	2.55	2.48	0.31	0.82
39	Mar. 27		2.80	2.69	2.57	2.54	2.49	0.31	0.72
40	Mar. 27		2.70	2.59	2.47	2.44	2.37	0.33	0.74
41	Mar. 28		2.64	2.50	2.37	2.35	2.30	0.34	0.74
42	Mar. 28		2.53	2.38	2.25	2.19	2.13	0.40	0.94
43	Mar. 28	Station 108	2.49	2.37	2.25	2.20	2.13	0.36	0.99
44	Mar. 29		2.60	2.49	2.38	2.34	2.27	0.33	0.91
45	Mar. 29		2.52	2.41	2.26	2.20	2.15	0.37	1.08
46	Mar. 29		2.43	2.33	2.19	2.03	1.95	0.48	1.31
47	Mar. 29		2.17	2.05	1.90	1.84	1.76	0.41	1.45
48	Mar. 31		2.27	2.17	2.03	2.00	1.95	0.32	1.29
49	Mar. 31	Station 109	1.99	1.88	1.71	1.64	1.58	0.41	1.73
50	Mar. 31		2.05	1.87	1.76	1.68	1.61	0.44	1.49
51	Mar. 31		2.44	2.32	2.15	2.09	2.04	0.40	1.16
52	Mar. 31		2.44	2.33	2.20	2.15	2.09	0.35	1.16
53	Apr. 1		2.66	2.56	2.43	2.38	2.34	0.32	1.03
54	Apr. 1		2.62	2.50	2.34	2.29	2.26	0.36	1.06
55	Apr. 1		2.51	2.36	2.22	2.15	2.10	0.41	1.16
56	Apr. 1	Station 110	2.38	2.22	2.04	1.97	1.91	0.47	1.24
57	Apr. 2		2.50	2.33	2.15	2.09	2.03	0.47	1.22
58	Apr. 2		2.46	2.29	2.12	2.07	2.01	0.45	1.22
59	Apr. 2		2.42	2.26	2.09	2.04	1.98	0.44	1.21
60	Apr. 2		2.36	2.18	2.03	1.97	1.91	0.45	1.14
61	Apr. 3		2.39	2.26	2.09	2.05	1.99	0.40	1.13
62	Apr. 3	Station 111	2.48	2.41	2.22	2.18	2.14	0.34	1.02
63	Apr. 3		2.60	2.50	2.33	2.30	2.24	0.36	1.07
64	Apr. 5		2.75	2.64	2.50	2.46	2.39	0.36	1.01
65	Apr. 5		2.84	2.74	2.59	2.55	2.49	0.35	0.97
66	Apr. 7		3.02	2.90	2.76	2.73	2.67	0.35	0.94
67	Apr. 8	Station 112	2.93	2.83	2.68	2.57	2.51	0.42	0.93
68	Apr. 8		2.56	2.47	2.30	2 21	2.14	0.42	1.37
69	Apr. 8		2.74	2.60	2.47	2.42	2.36	0.38	1.15
70	Apr. 8		2.88	2.78	2.62	2.44	2.39	0.49	1.03
71	Apr. 8		3.07	2.96	2.82	2.27	2.23	0.84	1.19
72	Apr. 8		3.09	2.97	2.81	1.93	1.87	1.22	1.51
73	Apr. 10		2.89	2.77	2.55	1.20	1.14	1.75	2.13
74	Apr. 11	Station 113	2.81	2.67	2.45	2.17	2.12	0.69	1.25
75	Apr. 11		2.92	2.80	2.61	2.48	2.43	0.49	1.01
76	Apr. 11		3.00	2.88	2.72	2.63	2.60	0.40	0.86
77	Apr. 17		3.05	2.93	2.78	2.71	2.66	0.39	0.88
78	Apr. 18		3.12	2.97	2.82	2.73	2.70	0.42	0.91
78½	June 30		2.57	2.40	2.24	2.15	2.11	0.46	1.39
79	June 14		2.28	2.08	1.89	1.78	1.72	0.56	1.24
80	June 14		2.31	2.11	1.91	1.80	1.73	0.58	1.08
81	June 16	Station 114	2.37	2.17	1.77	1.86	1.81	0.56	1.16
82	June 16		2.39	2.19	1.98	1.86	1.81	0.58	1.24
83	June 16		2.31	2.10	1.89	1.77	1.72	0.59	1.28
84	June 17		2.36	2.16	1.97	1.88	1.83	0.53	1.02
85	June 17		2.23	2.08	1.88	1.80	1.74	0.49	1.18
86	June 17		2.26	2.06	1.84	1.74	1.68	0.58	1.10
87	June 18	Station 115	2.27	2.04	1.82	1.73	1.67	0.60	1.17
88	June 18		2.32	2.09	1.87	1.80	1.73	0.59	1.25
89	June 18		2.31	2.10	1.87	1.81	1.75	0.56	1.24
90	June 19		2.20	2.00	1.78	1.72	1.66	0.54	1.26
91	June 19		2.21	2.01	1.78	1.72	1.66	0.55	1.29
92	June 19		2.09	1.87	1.68	1.60	1.55	0.54	1.38
93	June 30	Station 116	2.52	2.32	2.04	1.95	1.89	0.63	1.64
94	June 30		2.67	2.50	2.24	2.18	2.09	0.58	1.41
95	July 1		2.35	2.14	1.89	1.36	1.24	1.11	2.23

*Weight of concrete mixed partially rests upon this block and therefore its subsidence is not considered.

WEST JETTY, ABOVE STATION 101+25.

Number of block.	Date when laid.	Location of block.	Elevation in feet.					Total subsidence.	
			1880.			1881.			
			June 23.	September 15.	December 12.	March 25.	June 15.	Since June 23, 1880.	Since blocks were laid.
	1879.								
1	May 7	Station 101	2.54	2.40	2.31	2.27	2.22	0.32	0.46
2	May 8		2.70	2.56	2.46	2.39	2.37	0.33	0.42
3	May 8		2.66	2.52	2.43	2.36	2.31	0.35	0.46
4	May 8		2.89	2.71	2.63	2.50	2.48	0.41	0.51
5	May 9		2.89	2.59	2.47	2.40	2.37	0.52	0.84
6	May 9		2.54	2.39	2.33	2.26	2.23	0.31	0.45
7	May 9		2.17	2.02	1.94	1.91	1.87	0.30	0.47
8	May 10	Station 100	2.15	1.93	1.85	1.83	1.78	0.37	0.38
9	May 10		2.20	2.03	1.95	1.90	1.85	0.35	0.55
10	May 12		2.24	2.08	2.01	1.98	1.93	0.31	0.40
11	May 12		2.24	2.06	1.98	1.95	1.91	0.33	0.51
12	May 12		2.26	2.07	2.02	1 99	1.94	0.32	0.48
13	May 12		2.24	2.05	2.00	1.97	1.92	0.32	0.49
14	May 13	Station 99	2.17	1.98	1.90	1.87	1.81	0.36	0.54
15	May 13		2.11	1.94	1.84	1.80	1.76	0.35	0.53
16	May 13		2.15	1.96	1.88	1.82	1.78	0.37	0.56
17	May 13		2.27	2.07	2.00	1.94	1.90	0.37	0.54
18	May 13		1.99	1.79	1.72	1.67	1.62	0.37	0.57
19	May 13		2.05	1.86	1.80	1.76	1.73	0.32	0.54
20	May 14	Station 98	1.95	1.76	1.71	1.65	1.60	0.35	0.54
21	May 14		1.73	1.52	1.46	1.44	1.38	0.35	0.48
22	May 14		1.57	1.35	1.28	1.26	1.22	0.35	0.52
23	May 14		1.59	1.36	1.31	1.29	1.26	0.33	0.50
24	May 14		1.68	1.47	1.43	1.40	1.38	0.30	0.38
25	May 14		1.68	1.27	1.45	1.41	1.39	0.29	0.41
26	May 14	Station 97	1.51	1.27	1.22	1.19	1.18	0.33	0.47
27	May 14		1.49	1.26	1.21	1.17	1.14	0.35	0.53
28	May 15		1.51	1.30	1.23	1.19	1.17	0.34	0.56
29	May 15		1.45	1.27	1.19	1.15	1.13	0.32	0.56
30	May 15	Station 96	1.73	1.54	1.46	1.43	1.41	0.32	0.53
31	May 15		1.79	1.59	1.53	1.49	1.45	0.34	0.53
32	May 15		1.85	1.65	1.60	1.56	1.52	0.33	0.51
33	May 15		1.88	1.69	1.64	1.60	1.56	0.32	0.51
34	May 16	Station 95	1.81	1.62	1.54	1.53	1.48	0.33	0.53
35	May 16		1.88	1.70	1.63	1.61	1.55	0.33	0.51
36	May 16		1.86	1.68	1.61	1.61	1.56	0.30	0.48
37	May 16		1.73	1.57	1.50	1.51	1.47	0.26	0.40
38	May 17	Station 94	1.93	1.78	1.70	1.72	1.63	0.30	0.42
39	May 17		2.14	1.99	1.95	1.93	1.89	0.25	0.37
40	May 17		2.38	2.24	2.15	2.13	2.12	0.26	0.33
41	May 17		2.44	2.28	2.19	2.18	2.17	0.27	0.36
42	May 19	Station 93	2.42	2.29	2.21	2.21	2.19	0.23	0.33
43	May 19		2.43	2.31	2.23	2.22	2.20	0.23	0.34
44	May 19		2.56	2.42	2.36	2.34	2.34	0.22	0.27
45	May 20		2.54	2.39	2.35	2.33	2.33	0.21	0.27
46	May 20		2.69	2.54	2.49	2.45	2.45	0.24	0.29
47	May 20	Station 92	2.58	2.42	2.37	2.34	2.33	0.25	0.35
48	May 20		2.49	2.34	2.29	2.25	2.24	0.25	0.28
49	May 20		2.28	2.13	2.09	2.02	2.04	0.24	0.32
50	May 20		2.21	2.04	1.99	1.95	1.94	0.27	0.39
51	May 21	Station 91	2.30	2.17	2.11	2.07	2.04	0.26	0.38
52	May 21		2.47	2.33	2.28	2.25	2.23	0.24	0.35
53	May 21		2.54	2.39	2.36	2.30	2.29	0.25	0.40
54	May 21		2.55	2.41	2.37	2.34	2.32	0.23	0.34
55	May 21	Station 90	2.25	2.12	2.07	2.04	1.01	0.24	0.37
56	May 21		1.79	1.64	1.59	1.56	1.55	0.24	0.37
57	May 22		1.71	1.59	1.52	1.50	1.48	0.23	0.37
58	May 22		1.90	1.75	1.69	1.69	1.64	0.26	0.40
59	May 22	Station 88+97	2.07	1.93	1.88	1.86	1.84	0.23	0.39
Average subsidence of 154 blocks								0.38	0.79
Greatest subsidence (during the year) block 73								1.75	.....
Greatest subsidence (since blocks were laid) block 95								.....	2.23

Wing-dams.—During the month of July, 1880, a condemned model barge was sunk near the west shore, opposite a point 1,200 feet below East Point, to serve as a wing-dam; the inner or shore end was at average flood-tide, and 155 feet from this end the depth of water over the barge was 15 feet; 26 cubic yards of marl were used to aid in sinking it.

In September a wing-dam was constructed and sunk near the west shore, opposite a point 350 feet below East Point. This consisted of a coal barge 170 feet long, 26 feet wide, and 9.4 feet high, one side of which was built up to a height of 22 feet on one end and sloping to 9 feet on the other, in accordance with the slope of the bottom at the locality where it was placed, so that when in position the upper edge would be horizontal; this addition was braced by timbers leading from it to the bottom beams of the barge; twenty piles were driven to hold it in position, and it was sunk by scuttling, and afterwards 31 cubic yards of stone, 53 cubic yards of gravel, and 25 cubic yards of sand were thrown into it.

These two structures had but little effect in deepening or widening the channel at this point.

During the months of May and June the old wing-dam (*p*), opposite a point 1,820 feet below East Point, was extended 30 feet, and two new lattice-dams built on the same side, opposite points 110 and 1,020 feet below East Point. The lengths of the latter are, respectively, 103 and 194 feet, and the outer ends of each of the three are in 24 feet depth of water. For the first dam, 10 piles were driven, against which and the old remaining piles 205 linear feet of lattice work was placed. Lattice-dam No. 1 contains ten piles and 103 linear feet of lattice work, in five sections; No. 2 contains eighteen piles and 194 linear feet of lattice work, in nine sections. In these three structures thirty-eight piles, 8,642 feet B. M. scantling, and 1,193 bolts were used.

The lattice work for these dams is the same in construction as that described for those built in the pass itself, except that the openings are 12 instead of 18 inches square.

The locations of the above-described dams are shown on Chart No. 1.

Dredging.—During the year the dredging done at different localities has amounted in time to seventy-one days of ten hours each, as follows:

Sixteen days in the pass itself, $1\frac{3}{8}$ miles below Head of Passes.

Four days in the pass itself, near Bayou Grande.

Thirty-two days in the "channel through the jetties."

Nineteen days on the lump 700 feet beyond the end of the jetties.

On the 6th of July last year the depth of water on a lump, which has long existed 700 feet beyond the present end of the east jetty and 200 feet west of a line which is the prolongation of that jetty, was from 15.2 to 19.2 feet; after ten and a half days' dredging the depth over the same area was increased to from 23 to 29 feet.

The depth of water over this shoal decreased slightly from month to month, maintaining more than 22 feet up to March 1; after this time it shoaled somewhat faster, until on June 13 a depth of 17.2 feet was found on it (see Chart No. 3), but its area is small compared with what it was before any dredging was done. During last month this lump was again dredged and its area decreased, though the least depth remained about the same. (See Chart No. 2.)

Additional plant.—During the year twelve piles have been driven along the east shore above East Point for moorings; two flat-boats have been rebottomed; an addition built to one dwelling, and a building formerly used as a boarding-house, at the head of the pass, has been moved to this place, and by additions converted into two small tenement houses.

At times when, on account of a heavy sea rolling over the east jetty, work could not be prosecuted there, the force was employed in discharging ballast from vessels and distributing the same to raise the surface adjacent to dwellings and other buildings, above the tide-water.

Force employed.—The average force employed during the year, including officers, mechanics, foremen, laborers, &c., has been about seventy in number.

EXAMINATIONS AND SURVEYS.

The examinations and surveys made during the year have been reported to you monthly, and were as follows:

Periodical surveys to determine whether a channel of required dimensions had been maintained "through the jetties"; a complete survey of the pass, together with partial surveys at times to determine the depth at localities where shoaling was liable to decrease the depth to less than 26 feet; observations to determine the slope of South Pass and the discharge of the three passes; sediment, tidal, and velocity observations; levels on concrete work, &c., together with more extended surveys, charts of which accompany this report. All work during the year has been reduced, plotted, and the results tabulated herein or shown graphically on charts, so that but little is required descriptively to make them clearly understood.

AT THE HEAD OF PASSES.

The survey at this point was extended over the same area as that of last year, and is given on Chart No. 6. From an inspection of this chart and a comparison with that of last year, a considerable change is readily noted in the depth of Northeast Pass during the year. Last year there was a very small area above the mattress-sill which had a greater depth than 30 feet. This area has greatly increased during the year, the deepening extending up into the main river. The increase in depth over this area varies from 1 to 5½ feet.

On Chart No. 9 are given comparative cross-sections, I J, and G H, taken, respectively, 250 and 2,120 feet above Upper Dam. Their locations are shown on Chart No. 6. Profiles of lines, A B, C D, and E F (Chart No. 6), are also given on Chart No. 9. From an inspection of these profiles and cross-sections it will be seen that but little change has taken place in Southwest Pass, except below the mattress-sill, where it has deepened. The upper portion of the line designating 26 feet depth on the west shore of the pass has moved shoreward from where it was a year ago, and assumed a direction almost parallel to a tangent to east T-head extension at its junction with Upper Dam. From profile A B, we find that shoaling has taken place above a point which is 1,450 feet above Upper Dam, and below this point there is a deepening, which is greatest from 500 feet above this dam to 1,000 feet below it. Below station cluster the channel has shoaled in some places and deepened in others, there being, however, no remarkable change. The upper 1,200 feet in length of the line A B, passed through the center of the only area above Upper Dam which had a greater depth than 30 feet last year. The greater portion of this area has shoaled to a less depth than 30 feet, and what remains of it, having a greater depth than 30 feet, has joined with the 30-foot channel into Northeast Pass. That portion of the 26-foot curve above Upper Dam which designates the east side of the channel into South Pass has moved eastward a little, and, like the same curve near the west shore of Southwest Pass, has taken a direction parallel to a tangent to east T-head extension. East of this tangent the change has been a deepening, increasing in amount across Northeast Pass. Eleven hundred feet from the east shore of this pass there seems to be an area which has undergone little or no change, while between this point and the east shore there has been a shoaling.

The upper extremity of the line A B, divides the width of water-way almost equally, and from an inspection of Chart No. 6, it will be seen that Northeast Pass receives its volume of water from about the same width of section that the other two passes do.

Profile E F does not show the greatest change in Northeast Pass, but taken in connection with sections I J and G H, the change is readily noted.

The volume of water passing through the easterly break in the Upper Dam, goes directly into Northeast Pass, and the scour which it has created, as shown by section I J, has evidently increased the fall into this pass and thus drawn into it a portion of the volume which was previously entering the other passes. During the year there has been an unusual period of time during which the wind blew from a direction varying between north and west, the prevailing direction during these times being nearly northwesterly. The general direction of the deep channel in that portion of Northeast Pass, shown on Chart No. 6, is northwest, and this, too, is the direction of the main river above the passes, consequently the velocity and volume into this pass which is unobstructed, would be increased, while into the other passes it would be directed against the Upper Dam and the east T-head extension, and to some extent create a head of water and thereby still further increase the flow into Northeast Pass. The west shore of South Pass, from Dam No. 3 to opposite the foot of Crane Island, has cut away from 20 to 110 feet since 1875, being greatest opposite the island, and the channel shore of the lower half of the island has cut away from 20 to 50 feet. During the year the cutting on the west shore has been from 10 to 50 feet, and was confined to that portion opposite the island.

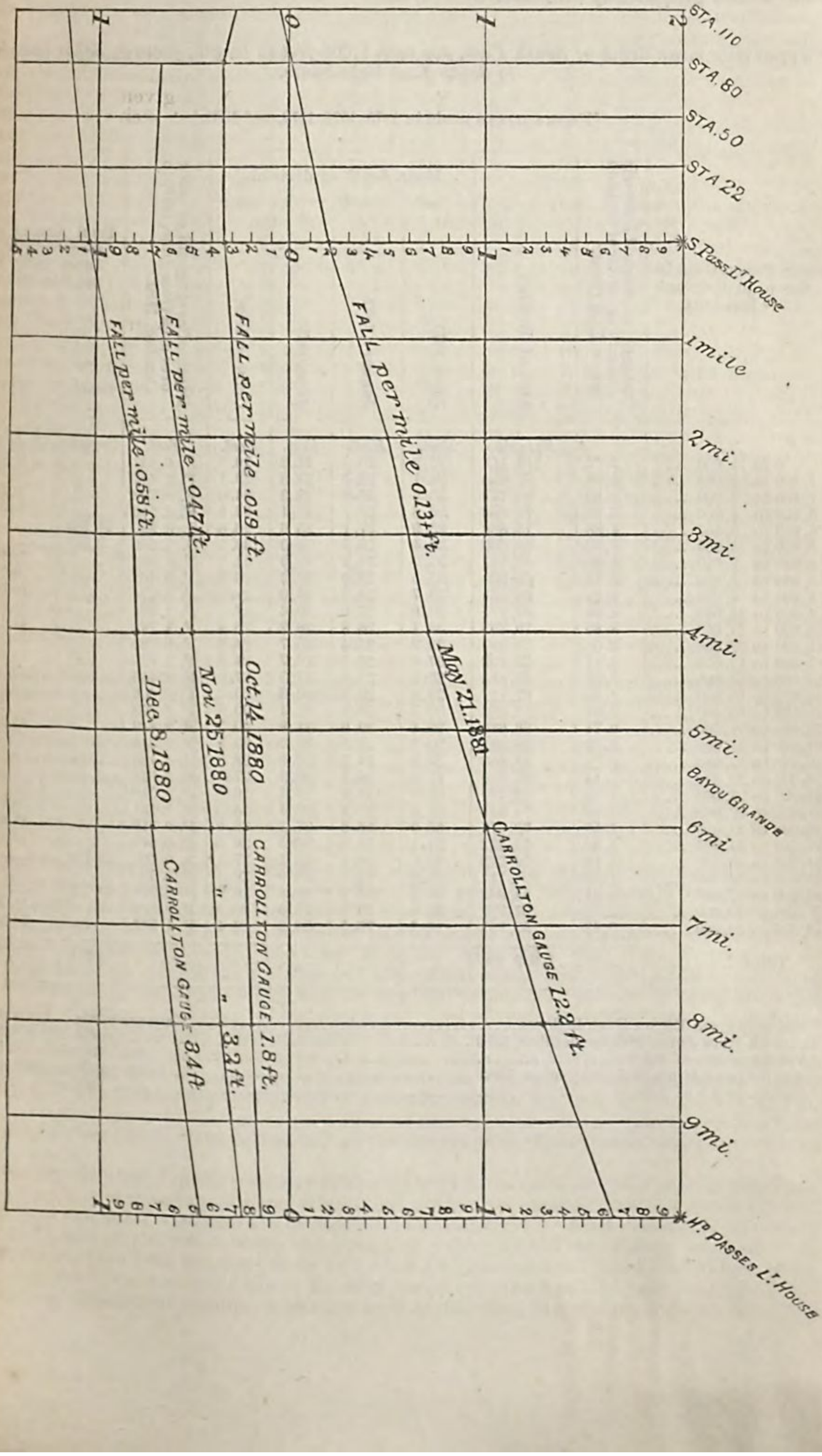
Discharge and slope observations.—It has been impracticable to make frequent observations to determine the discharge of the three passes; these are only of value when made at times when there is no tide, that is, at moon's zero declination, but at such times it frequently occurs that the weather is unfavorable or that more important work is required.

Three sets of observations were made during the year, but in two cases they were interrupted by storm.

On June 4, I made a set of observations under most favorable conditions; at this time the river's surface indicated 12.2 feet on the gauge at Carrollton, La., which stage it had maintained with but slight fluctuations for three months previous. These results show that South Pass was discharging 9.8 per cent.; Southwest Pass, 42.8 per cent.; and Northeast Pass, 47.4 per cent. of the total discharged by the three passes, and a comparison of them with previous results taken at the same stage of river shows the discharge of Northeast Pass to have been increasing since Upper Dam broke away

(December, 1879), while the other passes have slightly decreased; as compared with the mean of all previous results, these show a decrease of seven-tenths of one per cent. in South Pass, one per cent. in Southwest Pass, and an increase of 1.7 per cent. in Northeast Pass.

The results of observations made during the year to determine the slope of South Pass are given graphically on the following diagram:



SURVEY OF SOUTH PASS FROM ITS HEAD TO SOUTH PASS LIGHT-HOUSE.

During the month of October, while the river was at its low stage, a survey of South Pass was made and the results compared with those obtained in 1875 and 1879, from surveys made at the same stage of river. The Charts of this survey are Nos. 4 and 5; the results of the comparisons made are given in the following tables, and represented graphically on Chart No 7.

Comparative mean depth of South Pass, for each 1,000 *feet in length, from* △ *Bayou Grande to South Pass light-house.*

[From surveys made in 1875, 1878, 1879, and 1880.]

From Bayou Grande down, in divisions 1,000 feet long.	Distance in miles and decimals of a mile of center of division above East Point.	Area of division.	Mean depth of division.				Depth of average fill or scour over area from June, 1879, to October, 1880.	Total amount of scour or fill from June, 1879, to October, 1880.	
			June, 1875.	January, 1878.	June, 1879.	October, 1880.		Scour.	Fill.
		Sq. yds.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
0 to 1,000	5.73	101,111	25.2	20.7	21.2	20.7	F. 0.411	.....	13,852
1,000 to 2,000	5.54	91,666	24.1	22.6	23.8	23.1	F. 0.647	.....	19,769
2,000 to 3,000	5.35	82,777	25.6	25.6	25.3	24.6	F. 0.702	.....	19,370
3,000 to 4,000	5.16	76,666	26.8	25.7	26.1	24.5	F. 1.546	.....	39,508
4,000 to 5,000	4.98	73,888	25.9	27.1	25.6	26.6	S. 0.990	24,383	.....
5,000 to 6,000	4.79	66,666	28.4	29.5	30.0	30.2	S. 0.266	5,911	.....
6,000 to 7,000	4.60	61,111	31.2	31.9	32.0	31.1	F. 0.931	.....	18,965
7,000 to 8,000	4.41	63,333	31.5	29.0	29.3	28.9	F. 0.462	.....	9,753
8,000 to 9,000	4.22	65,555	30.7	29.8	30.6	28.3	F. 2.274	.....	49,691
9,000 to 10,000	4.04	67,777	30.6	29.0	29.6	27.7	F. 1.996	.....	45,094
10,000 to 11,000	3.85	70,555	30.1	26.8	28.2	26.4	F. 1.748	.....	41,110
11,000 to 12,000	3.66	75,000	29.3	25.4	25.7	24.9	F. 0.765	.....	19,125
12,000 to 13,000	3.47	75,000	27.4	26.5	26.7	24.9	F. 1.839	.....	45,975
13,000 to 14,000	3.28	68,888	30.2	27.8	27.5	27.0	F. 0.445	.....	10,218
14,000 to 15,000	3.09	61,111	29.4	29.1	30.6	30.0	F. 0.606	.....	12,344
15,000 to 16,000	2.90	56,666	30.3	29.3	31.4	30.8	F. 0.593	.....	11,201
16,000 to 17,000	2.71	56,666	29.4	30.6	31.8	29.3	F. 2.449	.....	46,258
17,000 to 18,000	2.52	58,333	30.5	29.3	30.0	29.4	F. 0.614	.....	11,939
18,000 to 19,000	2.33	61,666	27.9	29.1	29.0	28.8	F. 0.134	.....	2,754
19,000 to 20,000	2.14	65,000	27.5	26.3	28.3	27.9	F. 0.344	.....	7,453
20,000 to 21,000	1.95	72,777	25.7	25.0	26.5	26.0	F. 0.549	.....	13,318
21,000 to 22,000	1.76	74,444	23.9	22.4	26.4	25.3	F. 1.031	.....	25,584
22,000 to 23,000	1.57	72,777	25.0	26.6	27.3	26.6	F. 0.646	.....	15,671
23,000 to 24,000	1.33	72,222	24.1	24.7	26.5	26.0	F. 0.547	.....	13,169
24,000 to 25,000	1.19	72,222	23.7	26.5	26.1	27.1	S. 0.962	23,159	.....
25,000 to 26,000	1.00	71,111	24.4	28.0	26.9	26.4	F. 0.508	.....	12,041
26,000 to 27,000	0.81	68,888	25.6	26.3	25.8	26.7	S. 0.904	20,758	.....
27,000 to 28,000	0.62	67,777	26.0	26.8	26.9	26.3	F. 0.566	.....	12,787
28,000 to 29,000	0.43	58,333	26.5	26.5	28.2	26.4	F. 1.742	.....	33,872
Total	.....	1,959,986	.....	.....	.....	.....	.....	74,211	550,821

Total area from Bayou Grande down	square yards	1,959,986
Total fill from June, 1879, to October, 1880	cubic yards	476,610
Average depth of fill	feet	0.729
Total fill from June, 1875, to October, 1880	cubic yards	409,419
Average depth of fill	feet	0.627

Comparative mean depth of South Pass, for each 1,000 *feet in length, from* △ *Bayou Grande to head of Pass.*

[From surveys made in 1875, 1878, 1879, and 1880.]

From Bayou Grande up, in divisions 1,000 feet long.	Distance in miles and decimals of a mile above East Point.	Area of division.	Mean depth of division.				Depth of average fill or scour over area from June, 1879, to October, 1880.	Total amount of scour or fill from June, 1879, to October, 1880.	
			June, 1875.	January, 1878.	June, 1879.	October, 1880.		Scour.	Fill.
		Sq. yds.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
0 to 1,000	5.92	104,444	24.8	20.5	21.4	21.5	S. 0.111	3,864	.....
1,000 to 2,000	6.11	92,222	26.4	25.8	22.8	22.5	F. 0.313	.....	9,622
2,000 to 3,000	6.30	82,222	28.6	25.1	25.0	24.5	F. 0.430	.....	11,785
3,000 to 4,000	6.49	72,222	33.0	29.7	29.0	28.8	F. 0.213	.....	5,127
4,000 to 5,000	6.68	64,444	33.5	33.4	30.1	30.0	F. 0.119	.....	2,556
5,000 to 6,000	6.87	63,666	36.0	33.2	32.8	32.4	F. 0.354	.....	7,512
6,000 to 7,000	7.06	68,333	34.2	30.0	32.1	30.8	F. 1.333	.....	30,362
7,000 to 8,000	7.25	67,222	33.8	29.8	30.8	29.7	F. 1.132	.....	25,365
8,000 to 9,000	7.44	62,222	32.6	31.7	30.7	32.1	S. 1.368	28,373	.....
9,000 to 10,000	7.63	63,333	37.0	32.2	31.0	31.6	S. 0.635	13,405	.....
10,000 to 11,000	7.82	67,777	35.5	33.4	30.0	28.4	F. 1.607	.....	36,306
11,000 to 12,000	8.01	68,888	35.8	31.5	29.8	27.4	F. 2.439	.....	56,006
12,000 to 13,000	8.20	67,777	36.1	31.0	28.1	28.1	S. 0.045	1,016	.....
13,000 to 14,000	8.39	70,000	36.3	31.3	29.6	29.5	F. 0.174	.....	4,060
14,000 to 15,000	8.58	94,444	33.8	25.6	21.6	23.0	S. 1.346	42,373	.....
15,000 to 16,000	8.77	122,777	26.4	20.7	16.7	18.3	S. 1.626	66,545	.....
16,000 to 17,000	8.96	113,333	23.1	18.3	18.8	20.0	S. 1.193	45,069	.....
17,000 to 18,000	9.14	105,555	27.2	22.2	20.4	21.2	S. 0.800	28,148	.....
18,000 to 19,000	9.33	95,000	27.6	23.5	23.2	23.6	S. 0.388	12,286	.....
19,000 to 20,000	9.52	84,444	29.2	24.9	25.5	26.0	S. 0.569	16,016	.....
20,000 to 21,000	9.71	77,777	33.4	25.2	28.1	30.4	S. 2.300	59,629	.....
21,000 to 22,000	9.90	72,222	36.2	28.4	32.1	38.9	S. 6.832	164,476	.....
22,000 to 23,000	10.09	80,888	36.3	31.2	32.8	34.2	S. 1.433	38,637	.....
Total	.....	1,861,212	.....	.....	.....	.....	.....	519,837	188,701

Total area from Bayou Grande up	square yards..	1,861,212
Total scour from June, 1879, to October, 1880	cubic yards..	331,136
Average depth of scour	feet..	0.531
Total fill from June, 1875, to October, 1880	cubic yards..	2,833,719
Average depth of fill	feet..	4.567
Total area of Pass	square yards..	3,821,198
Total fill from June, 1879, to October, 1880	cubic yards..	145,474
Average depth of fill	feet..	0.114
Total fill from June, 1875, to October, 1880	cubic yards..	3,243,138
Average depth of fill for the whole Pass	feet..	2.544

The above results show an average fill throughout the Pass of one-tenth of a foot during the year, and of 2$\frac{6}{7}$ feet since 1875. The portion below Bayou Grande shows an average shoaling of seven-tenths of a foot during the year, and of six-tenths of a foot since 1875, while the portion above Bayou Grande shows a scour of five-tenths of a foot during the year, and a shoaling of 4$\frac{1}{2}$ feet since 1875.

From an inspection of the profiles and cross-sections on Chart No. 7, the locations of the greatest and least shoaling will be readily noted, and it will be seen that the greatest shoaling has taken place along the line of deepest water and at localities where the Pass is widest. In June, 1879, the total length of Pass which showed a less depth than 30 feet was five-tenths of a mile; and in October, 1880, this length had been increased to 1.4 miles, the greatest shoaling being near to and above Bayou Grande. The profiles above referred to are continued to the ends of the jetties, and an inspection of them gives one a good idea of the amount of material which has been removed from the bar which obstructed the entrance to South Pass before the jetties were built.

On May 10, 1881, I made a survey at the locality 1$\frac{8}{8}$ miles below the head of the Pass, and found that the channel here, which had previously shoaled to a less depth than 26 feet (see Appendix A, certificate of May 9), had increased in depth, owing to the effect of the lattice-dams, which were completed at this locality three days previous. At this time I found the least depth to be 28 feet and the least width of the 26-foot channel 130 feet. On June 20 I made another survey at this locality, and found that the width of the 26-foot channel had increased to 190 feet, but the least depth remained

about the same as before. This latter survey is shown on Chart No. 5. The width of the 26-foot channel near Bayou Grande has increased since October, and is now 160 feet, with a least central depth of 27 feet. These are the minimum channel dimensions at present from the main river to the Gulf of Mexico.

The channel through the jetties.—The channel through the jetties is shown on Charts Nos. 1 and 2. In Appendix A I have given copies of the certificates which you have issued during the year, as they give information regarding the maintenance of channel, not only throughout the jetties, but throughout the Pass.

This channel has undergone slight fluctuations during the year, and with but little dredging has maintained the required dimensions, as is shown by the following table:

Tabulated statement giving the minimum depths and widths of channel through the jetties, in separate reaches of 2,000 *feet each, according to surveys made monthly during the fiscal year ending June* 30, 1881.

[Distances from East Point, in feet.]

Date on which soundings were made.	0–2000.			2,000–4,000.			4,000–6,000.		
	Least depth.	Least width for—		Least depth.	Least width for—		Least depth.	Least width for—	
		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.
1880.									
June	31	200	50	32. 5	270	50	47. 8	350	290
July	30. 5	210	40	31	290	50	44	320	280
August	30. 5	200	30	30. 4	230	30	46	320	250
September	30. 7	200	30	31	240	30	44. 4	330	250
October	31	200	50	31. 5	270	50	41	340	260
November	30. 6	200	30	31. 0	260	50	40. 3	335	255
December	30. 9	230	20	30. 6	270	40	43	310	270
1881.									
January	30. 5	230	30	30. 4	250	30	41. 9	340	240
February	30. 4	240	40	30. 2	275	50	41. 6	310	230
March	31. 5	240	40	31. 2	280	60	41. 3	340	260
April	30. 4	240	60	30. 0	290	50	43	420	280
May	30. 2	220	30	30. 5	280	30	42. 7	390	260
June	30	250	20	30. 5	280	40	43. 8	340	290

Date on which soundings were made.	6,000–8,000.			8,000–10,000.			10,000–12,000.		
	Least depth.	Least width for—		Least depth.	Least width for—		Least depth.	Least width for—	
		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.		26-foot depth.	30-foot depth.
1880.									
June	31. 4	250	120	35. 1	260	120	32. 0	300	130
July	30. 8	240	50	31. 5	240	70	30. 3	210	30
August	32	270	90	32. 0	230	70	30. 3	220	50
September	30. 6	200	60	32. 0	220	70	31. 0	230	30
October	30. 3	210	40	31. 0	210	60	30. 5	220	30
November	30. 8	200	50	30. 9	215	60	30. 5	215	25
December	30. 8	235	75	31. 0	210	45	30. 3	220	25
1881.									
January	33. 8	230	80	30. 7	220	50	30. 3	210	30
February	32. 0	200	70	31. 0	200	40	30. 0	200	20
March	32	250	70	32. 0	220	80	30. 5	250	70
April	33	230	90	33. 0	240	60	30. 5	250	70
May	32. 6	270	90	30. 5	230	50	31. 2	240	60
June	32	230	100	31. 7	240	120	31. 7	230	60

The least depth through the jetties at present is 30 feet, and the least width of the 30-foot channel is 20 feet; this is at a locality 1,200 feet below East Point; the least width of the 26-foot channel is 230 feet. On June 24, the width of the 26-foot channel between the lumps seaward of the end of east jetty was found to be but 110 feet; this

width was increased by dredging and found to be 210 feet on the 28th instant, and dredging has since been continued at this location. A channel of more than 40 feet depth has scoured between the ends of the jetties, commencing 450 feet above them and extending over a length of 900 feet, curving in a direction around the end of the east jetty (see Chart No. 2). The following table gives the minimum depths of channel through the jetties, at various dates since the commencement of the works, and serves to show the channel improvement from that time to the present.

Table showing depths through the jetties at various dates.

Date.	Distances from East Point, in feet.					
	0 to 2, 000	2, 000 to 4, 000	4, 000 to 6, 000	6, 000 to 8, 000	8, 000 to 10, 000	10, 000 to 12, 000
1875.						
June	22. 5	18. 7	16. 7	10. 2	9. 7	9. 2
1876.						
May	23. 3	20. 3	22. 0	21. 0	17. 1	15. 0
August	23. 5	19. 6	21. 0	23. 5	23. 0	19. 8
November	22. 0	20. 3	21. 1	21. 2	21. 1	20. 3
1877.						
March	24 1	21. 1	23. 2	22. 0	21. 2	20. 5
July	24. 9	24. 0	26. 0	23. 8	23. 5	20. 3
October 25, to December 14	26. 3	24. 4	28. 5	24. 2	23. 0	23. 7
1878.						
March	26. 0	25. 9	35. 5	25. 4	24. 3	23. 0
December	28. 4	26. 4	35. 7	27. 1	25. 3	23. 0
1879.						
March	28. 6	27. 5	43. 4	27. 0	27. 0	27. 0
June	27. 5	28. 4	47. 7	29. 2	29. 2	28. 0
July 8	30. 5	30. 7	.....	31. 0	30. 7	30. 5
December	31. 0	31. 0	48. 3	31. 7	31. 8	30. 8
1880.						
June	31. 0	32. 5	47. 8	31. 4	35. 1	32. 0
July	30. 5	31. 0	44. 0	30. 8	31. 5	30. 3
August	30. 5	30. 4	46. 0	32. 0	32. 0	30. 3
September	30. 7	31. 0	44. 4	30. 6	32. 0	31. 0
October	31. 0	31. 5	41. 0	30. 3	31. 0	30. 5
November	30. 6	31. 0	40. 3	30. 8	30. 9	30. 5
December	30. 9	30. 6	43. 0	30. 8	31. 0	30. 3
1881.						
January	30. 5	30. 4	41. 9	33. 8	30. 7	30. 3
February	30. 4	30. 2	41. 6	32. 0	31. 0	30. 0
March	31. 5	31. 2	41. 3	32. 0	32. 0	30. 5
April	30. 4	30. 0	43. 0	33. 0	33. 0	30. 5
May	30. 2	30. 5	42. 7	32. 6	30. 5	31. 2
June	30. 0	30. 5	43. 8	32. 0	31. 7	31. 7

The depth of water east of the east jetty and west of the west jetty remains about the same as it was last year, below the Sand Reefs, while above them it is decreasing gradually, and marsh grass is growing over a considerable portion of these areas; where there is water it is less than half a foot in depth at average flood-tide.

SURVEY BEYOND THE ENDS OF THE JETTIES.

I now come to the consideration of an area the surveys of which form a most interesting and important chapter in connection with the Mississippi jetties. All questions regarding the condition of the jetties, their future, &c., seem to be absorbed by this one question—Is there a new bar forming in front of the jetties? I will endeavor to present the results of investigations, extending over a period of years, in such a way that the fair-minded investigator may be able to answer this question and all others which may arise regarding the changes which have taken place seaward from the ends of the jetties.

The area which has been sounded since 1876 contains a fraction more than 2 square miles; 1¼ square miles of this area is subdivided into twenty-one divisions, and the mean depth of each division and finally of the whole is obtained and compared with results obtained in the same way for previous years. The total area surveyed is then considered by measuring ordinates 100 feet apart to each curve designating depths, and the means of these ordinates compared with similar results obtained from previous surveys, and in this way we ascertain whether these curves are nearer to or more remote from the ends of the jetties than they were previously; that is, we determine whether there is a shoaling or a scour, or whether the bar is advancing or receding.

The results seaward from the ends of the jetties of course depend largely upon their condition; during previous years they have been in process of construction, and considerable water was escaping over them, but during the past year they have remained in good condition, confining the water in a channel between them until it was discharged between their ends. This condition alone makes the results of this year more valuable and interesting than those for any previous year. The changes in the Gulf are of course dependent upon other conditions, such as the stage of the river during the year, the character and amount of sediment transported, &c,

To one who wishes to gain an idea of the change which is taking place beyond the ends of the jetties without going into details, the most simple comparison is by placing a tracing of one chart upon that of another and following the curves designating different depths and noting the changes in the position of each curve between the two dates. This comparison is very confusing, however, on account of the soundings on the charts, and also on account of curves designating different depths becoming intermingled at localities where there is considerable change; but we may trace these curves from the two superposed charts on to one chart and then by distending it, so to speak, separate curves of different depths, while those of the same depth maintain the same relative position with relation to each other. This comparison is shown on Chart No. 7. The survey of 1876 did not extend as far to the westward as succeeding surveys have, and, in order to compare these surveys with that of 1876, I have omitted that portion of each curve on the later charts which has no corresponding portion on the chart of 1876. From an inspection of Chart No. 7 a decided advance of all the curves with the exception of the central and eastern portions of the 20 and 30 foot and the central portion of the 50-foot curves will be noted, and these, as will be shown further on, have receded slightly. I will now proceed with a comparison of the results obtained for each year from 1876 to 1881, inclusive, by mean ordinates; and in these comparisons I will endeavor to satisfy the objections which some investigators have offered to our results previously obtained on the ground that a portion of the area considered was to the eastward and westward of the track of the river's discharge. Each curve has been considered in three parts, one of which extends over an area which is indisputably in the track of the river's discharge, the other portions being to the eastward and westward of this; and the results will, I think, show that whether the area in the track of the river's discharge or an area to the eastward and westward of it be considered, each separately or the whole taken together, the same general conclusion will be arrived at, and that is that there is a shoaling going on beyond the ends of the jetties, except over a limited area directly in front of them, where a deepening has taken place. The lines *ab* and *cd* on Charts Nos. 3 and 8 divide the areas considered; the mean ordinate of that portion of each curve which is east of the line *ab* and west of the line *cd*, and also the portions between these lines, are each determined separately and then combined, giving the mean ordinate of the whole curve. These results are shown on Plate I.

A detailed account of the changes from year to year of each separate portion of each curve would be superfluous, since these diagrams sufficiently explain them, and a general statement of the results when each curve is *considered as a whole* will, I think, be sufficient. It will be seen that from 1876 to 1878 there was a recession of all the curves up to and including that designating 70 feet depth; from 1878 to 1881 all but the 20-foot curve advanced, and this continued receding until 1879, and then advanced. From 1878 to 1879 there was a decided advance of all the curves, except the 20-foot, and this advance increased with the depth of water, being greatest for the curve designating 100 feet depth. The next decided advance of the curves is shown from 1880 to 1881, but unlike the change from 1878 to 1879 this shows the advance to decrease as the depth of water increases, until finally the 100-foot curve for this period shows a recession, the 30-foot curve showing the greatest advance; all, however, show an advance since 1876, which increases with the depth of water, being least for the 20-foot curve and greatest for the 90.

The results of comparison made between 1876 and 1881 are given in detail on Plate II. In these comparisons each curve is considered in three parts and then as a whole, as previously explained; the ordinates of each curve for 1876 are assumed to be zero, then the length of each ordinate in 1881 will denote the distance that each curve, or portion of the curve, has moved, *negative ordinates denoting recession, and positive ones advance*, the distance in feet being given on the right of the diagrams.

From an inspection of Part No. 1, Plate II, we see the results which were apparent from an inspection of Chart No. 8, that is, that with the exception of the central and eastern portions of the 20 and 30 foot curves, and the central portion of the 50-foot curve, all have advanced, the eastern portion showing the greatest advance, which increases with the depth of water, while the western portion shows the advance to decrease with an increased depth. The central portions show the greatest fluctuations, denoting a recession of 89 feet for the curve designating 20 feet depth, 101 feet for that of 30 feet depth, and 160 feet for that designating 50 feet depth, while the other curves show an advance, which is greatest for the 90-foot curve and least for for the 70.

Part No. 2 of this plate gives the results of the comparisons when the mean of all the ordinates measured for each curve is considered, and shows that each curve has advanced from its position in 1876. The results given on these plates furnish good evidence that the area most directly in front of the jetties is undergoing the same changes though in a less degree than the areas to either sideof it are.

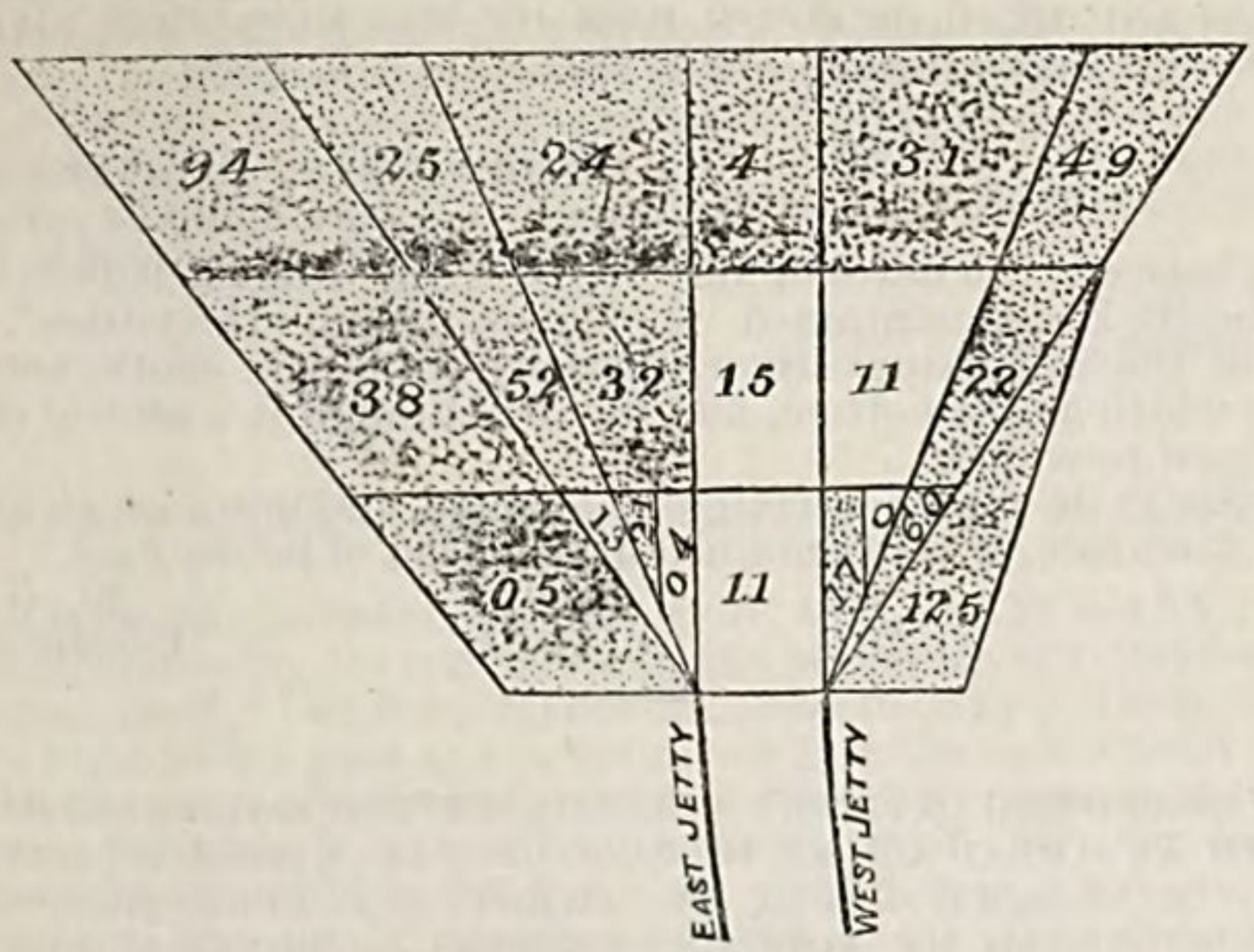
The *fan-shaped area* and its twenty-one subdivisions is shown on Chart No. 3, and the following table gives the results of comparisons at different dates in detail, which have been made to ascertain the amount of shoaling or scour over this area, which contains 1¼ square miles seaward of the ends of the jetties.

Number of subdivision.	Area of subdivision in square feet.	Mean depth of subdivision, in feet.						Quantity of water overlying subdivision, in cubic yards.						Mean depth over whole area.	
		1876.	1877.	1878.	1879.	1880.	1881.	1876.	1877.	1878.	1879.	1880.	1881.	Date.	Mean depth
1	3,359,484	98.0	86.3	93.13	89.47	93.87	88.68	12,193,680	10,737,893	11,712,156	11,133,335	11,680,428	11,033,790		
2	1,951,904	73.0	76.43	78 12	71.79	70.05	70.50	5,277,360	5,525,320	5,647,511	5,190,423	5,064,106	5,097,072		
3	3,203,900	72.524	73.458	72.38	69.32	67.91	70.11	8,606,200	8,716,392	8,588,820	8,225,954	8,058,639	8,319,105	June, 1876	60.78
4	1,771,511	67.455	67.877	66.40	61.32	61.92	63.46	4,425,860	4,453,514	4,356,630	4,023,625	4,062,665	4,163,967		
5	3,195,900	75.342	73.319	77.60	74.26	76.47	72.21	8,917,980	8,678,488	9,185,253	8,789,980	9,051,617	8,547,376		
6	1,951,904	76.724	81.0	75.34	74.12	75.57	71.81	5,546,570	5,855,700	5,446,535	5,358,410	5,463,379	5,191,196	June, 1877	60.38
7	3,146,568	63.63	62.45	66.38	62.66	63.57	59.82	7,415,403	7,277,886	7,735,899	7,303,062	7,408,419	6,971,623		
8	1,177,965	58.40	59.50	59.74	58,30	58.62	53.23	2,547,905	2,595,882	2,606,356	2,543,532	2,557,449	2,322,466		
9	1,911,590	53.7826	53.892	56.30	56.58	52.63	50.59	3,807,800	3,815,012	3,986,015	4,005,839	3,726,397	3,581,962	July, 1878	62.18
10	1,804,280	47.9336	48.845	51.83	47.70	49.12	49.41	3,203,170	3,264,076	3,463,548	3,187,621	3,282,921	3,302,099		
11	1,910,900	52.4822	54.075	56.38	54.54	54.80	53.53	3,714,389	3,827,022	3,990,242	3,860,303	3,878,490	3,788,890		
12	1,177,965	50.5625	52.144	49.97	51.05	50.75	48.35	2,205,950	2,274,950	2,180,110	2,227,400	2,214,138	2,109,604	July, 1879	59.62
13	2,664,385	36.803	38.438	39.57	40.35	39.67	36.34	3,631,752	3,793,096	3,904,805	3,982,775	3,914,672	3,586,460		
14	354,931	31.464	37.02	35.00	34.73	33.63	32.76	413,612	486,650	460,095	456,546	442,086	430,649		
15	196,900	35.20	36.325	40.01	40.26	35.26	33.11	256,699	264,803	291,766	293,599	257,159	241,468	June, 1880	59.74
16	395,320	33.377	36.471	35.92	39.01	37.43	33.74	488,689	533,908	525,922	571,281	548,133	494,018		
17	1,658,310	29.2805	33.256	32.20	33.16	32.64	30.32	1,798,376	2,042,546	1,977,689	2,036,957	2,004,528	1,862,282		
18	390,660	31.444	32.905	34.00	35.92	33.07	29.75	454,959	476,003	491,942	519,838	478,515	430,449	June, 1881	57.36
19	195,900	37.0833	35.1	39.43	39.47	37.69	37.17	269,090	254,585	286,086	286,413	273,469	269,696		
20	354,931	35.654	36.85	37.20	33.47	32.99	29.62	468,690	484,415	489,016	440,088	433,686	389,439		
21	1,942,785	35.012	31.723	36.50	30.93	28.17	22.55	2,519,288	2,282,681	2,626,357	2,225,567	2,027,548	1,622,656		
	*34,717,993	1,095.1537	1,107.378	1.134.40	.....	.....	.....	78,163,422	77,640,825	79,952,753	76,662,548	76,828,444	73,756,267		

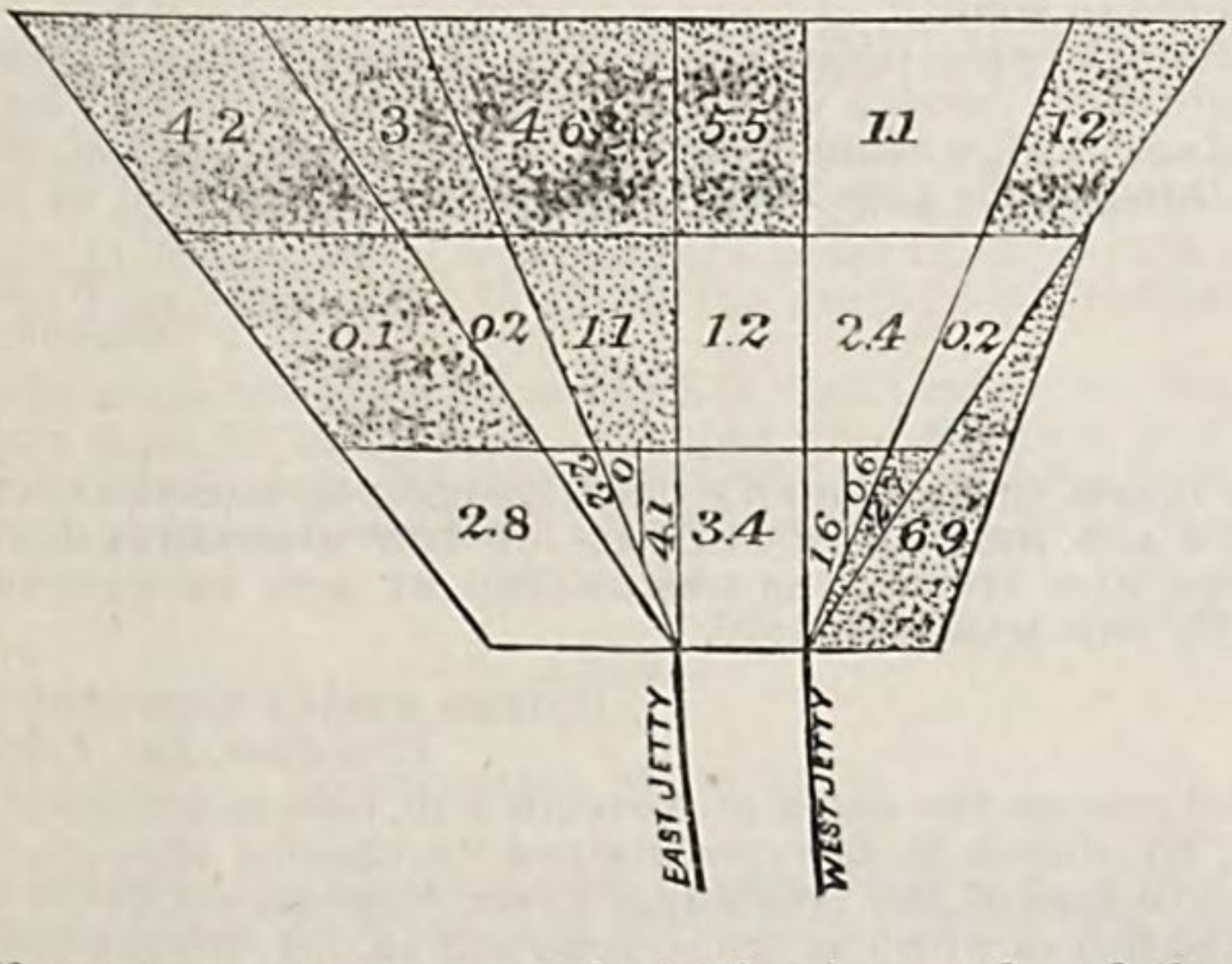
*Square miles, 1.2453.

	Feet.
Mean fill over whole area from 1876 to 1877	0.40
Mean scour over whole area from 1877 to 1878	1.80
Mean fill over whole area from 1878 to 1879	2.56
Mean scour over whole area from 1879 to 1880	0.12
Mean fill over whole area from 1880 to 1881	2.38
Mean fill over whole area from 1876 to 1881	3.42

The accompanying diagram, representing the fan-shaped area, presents the changes in this area from 1876 to 1881, and shows the amount and character of the same. The figures in each subdivision are the differences between the mean depths in those divis-



ions in 1876 and 1880, and therefore denote the amount of the change in each; shaded areas denote shoaling and blank areas scour. To show how variable the changes in this area are, and how differently the current seems to act upon the bar from year to year, I give another diagram, showing the changes over the same area from 1876 to 1880. These results show that the central belt of areas changed but little during this



period, while those nearest the ends of the jetties deepened, and those most remote shoaled. A theory, regarding the action of the current over this area, which would seem to follow from these facts, could not, as we see, be substantiated by later results, which simply shows that theories and predictions as to what will take place beyond the ends of the jetties, cannot be based upon the results thus far determined. In conclusion, acknowledgments are due to Assistant Engineer, Thos. L. Raymond for faithful and efficient services rendered during the year, and to Mr. G. W. Lawes for valuable assistance in the office.

Very respectfully, your obedient servant,

C. DONOVAN,
Assistant Engineer.

Capt. W. H. HEUER,
Corps of Engineers, U. A. S.

A.

UNITED STATES INSPECTING OFFICER'S CERTIFICATE FOR MAINTENANCE OF CHANNEL AT SOUTH PASS AND HEAD OF SOUTH PASS OF THE MISSISSIPPI RIVER, AS DESIGNATED BY AN ACT OF CONGRESS APPROVED MARCH 3, 1879.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., August 9, 1880.

I certify that between the dates of May 10, 1880, and August 9, 1880, both dates inclusive, Mr. James B. Eads maintained "a channel through the jetties" at the mouth of South Pass of the Mississippi River, "twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet without regard to width."

Also, during the same period a navigable channel, having a greater depth than 26 feet at average flood-tide, was maintained at the head of South Pass.

W. H. HEUER,
Captain of Engineers.

UNITED STATES INSPECTING OFFICER'S CERTIFICATE FOR MAINTENANCE OF CHANNEL AT THE MOUTH AND HEAD OF SOUTH PASS OF THE MISSISSIPPI RIVER, AND FOR SECURING A "NAVIGABLE DEPTH OF TWENTY-SIX FEET THROUGH THE PASS ITSELF," AS DESIGNATED BY ACTS OF CONGRESS APPROVED MARCH 3, 1875, AND MARCH 3, 1879.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., November 9, 1880.

I certify that between the dates of August 10, 1880, and November 9, 1880, both dates inclusive, Mr. James B. Eads maintained "a channel through the jetties" at the mouth of South Pass of the Mississippi River, "twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet without regard to width."

Also, that during the same period a navigable channel, having a greater depth than 26 feet, was maintained through the shoal at the head of South Pass; and further, that by September 3, 1880, a channel having "a navigable depth of twenty-six feet" was "secured through the pass itself." Depths were measured at "average flood-tide."

W. H. HEUER,
Captain of Engineers.

UNITED STATES INSPECTING OFFICER'S CERTIFICATE FOR MAINTENANCE OF CHANNEL AT THE MOUTH AND HEAD OF SOUTH PASS OF THE MISSISSIPPI RIVER, AND ALSO "THROUGH THE PASS ITSELF," AS DESIGNATED BY ACTS OF CONGRESS APPROVED MARCH 3, 1875, AND MARCH 3, 1879.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., February 9, 1881.

I certify that between the dates of November 10, 1880, and February 9, 1881, both dates inclusive, Mr. James B. Eads maintained "a channel through the jetties" at the mouth of South Pass of the Mississippi River, "twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet without regard to width."

Also, that during the same period a channel having "a navigable depth of twenty-six feet was maintained through the shoal at the head of South Pass and through the pass itself." Depths were measured at "average flood-tide."

W. H. HEUER,
Captain of Engineers.

UNITED STATES INSPECTING OFFICER'S CERTIFICATE FOR THE MAINTENANCE OF CHANNEL AT THE MOUTH AND HEAD OF SOUTH PASS OF THE MISSISSIPPI RIVER, AS DESIGNATED BY ACTS OF CONGRESS APPROVED MARCH 3, 1875, AND MARCH 3, 1879.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., May 9, 1881.

I certify that between the dates of February 10, 1881, and May 9, 1881, both dates inclusive, Mr. James B. Eads maintained "a channel through the jetties" at the mouth

of South Pass of the Mississippi River, "twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet without regard to width."

Depths were reduced to the plane of "average flood-tide," which is indicated by a reading of 2.76 feet on United States engineers' gauge at South Pass light-house. During the above-mentioned period a channel having a "navigable depth of twenty-six feet" was maintained through the shoal at the head of South Pass. Depths at this point were reduced to a plane indicated by a reading of 1.8 feet on United States engineers' gauge at head of Passes light-house.

W. H. HEUER,
Captain of Engineers.

CERTIFICATE REGARDING THE DEPTH OF WATER "THROUGH THE PASS ITSELF."

I certify that between the dates of February 10, 1881, and March 23, 1881, both dates inclusive, a channel having "a navigable depth of twenty-six feet" was maintained "through the pass itself," but from March 24, 1881, to May 9, 1881, such "navigable depth" did not exist in the pass at a point about $1\frac{3}{8}$ miles below head of Passes light-house, when depths are reduced to a plane indicated by a reading of 1.8 feet on gauge at head of Passes light-house. Considering the stage of the river during this latter period, the actual depth would be 1.7 feet more at high-tide, 1.2 feet more at low-tide, and 1.5 feet more at mean-tide, than when reduced to the plane above referred to.

If a plane of reference in conformity with the opinion of the Board of Engineers appointed by Special Orders 229, Headquarters of the Army, Adjutant General's Office, November 2, 1876, be used, that is, if the measure of depths "be from the level of average high-tides occurring during the stage of the river when the volume is least," then the depth would be 0.6 foot more than if reduced to a plane indicated by a reading of 1.8 feet on gauge.

The following are therefore the results according to the above statements, viz:

1. In the first case, that is, when depths are reduced to a plane indicated by 1.8 feet on gauge, the distance over which "a navigable depth of twenty-six feet" did not exist (from March 24, 1881, to May 9, 1881) was 240 feet, and the least depth over this area was 25 feet.

2. If the stage of river at the time the soundings were made be considered, then "a navigable depth of twenty-six feet" did exist throughout the quarter from February 10 to May 9, 1881, inclusive, for in this case the plane of the river's surface at low-tide was 1.2 feet above the plane to which the depths were reduced (1.80 feet on gauge).

3. If the depths are reduced to a plane which is "the mean of the high-waters of the river at this place taken for one or more lunations when the river is at what is known as its low stage," then the least depth would be 25.6 feet, and the distance over which "a navigable depth of twenty-six feet" did not exist would be 240 feet.

W. H. HEUER,
Captain of Engineers.

FINANCIAL STATEMENT.

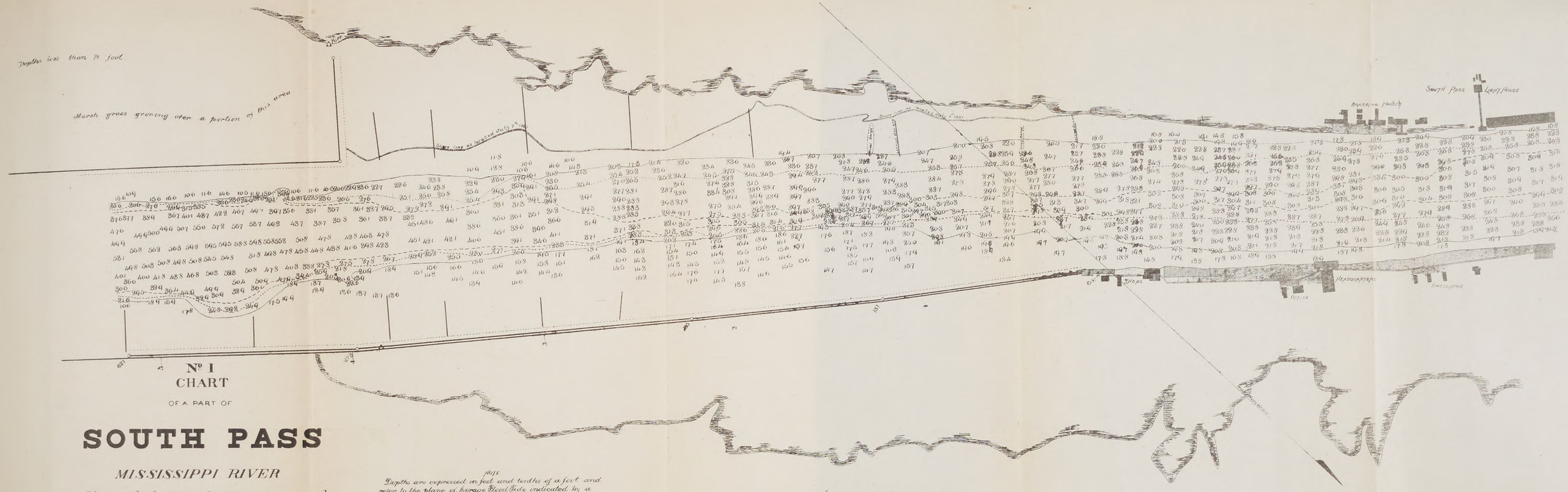
Amount available from appropriations for examinations and surveys at South Pass of the Mississippi River, July 1, 1880	$25,156 22	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$35,156 22
Amount expended during the fiscal year ending June 30, 1881, as follows, viz:		
As per accounts of Capt. W. H. Heuer	12,852 30	
As per accounts of Capt. D. W. Lockwood	7 58	
		12,859 88
Amount available July 1, 1881		22,296 34

ESTIMATE OF FUNDS REQUIRED FOR EXAMINATIONS AND SURVEYS AT SOUTH PASS OF THE MISSISSIPPI RIVER, DURING THE FISCAL YEAR ENDING JUNE 30, 1883.

Two assistant engineers	$3,560 00
One clerk	900 00
One steam engineer	1,200 00
One water-level observer	120 00

Six seamen	$4,740 00
Rent of office	300 00
Rent of assistant engineers' quarters	240 00
Mileage and traveling expenses	100 00
Fuel for launches	780 00
Repairs to launches and boats	1,500 00
Materials and supplies for launches	500 00
Stationery and supplies for office	100 00
Contingencies	2,500 00
Total	16,540 00

W. H. HEUER,
Captain of Engineers.



Nº 1
CHART
OF A PART OF

SOUTH PASS
MISSISSIPPI RIVER

Showing the location of jetties at its mouth.

SURVEYED AND PLOTTED BY ORDER
OF
Capt W.H.HEUER, Corps of Engr's, U.S.A.
BY
C Donovan, Assist Engineer
ASSISTED BY
T L Rockwood, Asst Engr

NOTE
Depths are expressed in feet and tenths of a foot and refer to the plane of Average Flood Tide indicated by a reading on 24 feet on the Engineers gauge at South Pass Light House

Soundings taken June 26th and 30th 1881
Carrollton gauge reading 9.6 ft

CONTOURS
20 ——— 26 ——— 30

New Orleans La. July 1st 1881
Forwarded to the Chief of Engineers U.S.A.
with annual report for the year ending June 30th 1881
W.H.Heuer
Captain of Engineers U.S.A.


GULF OF MEXICO
Chart
№ 2
CONTINUATION OF № 1
NOTE
Soundings taken June 25th and 28th 1881
CONCRETE BLOCKS represented thus
" with rubble parapet
" concrete
Cement
PELICAN KEY
Depth less than ½ foot
Marsh grass growing over a portion of this area
BASE LINE REEF
Scale
New Orleans La. July 18th 1881.
Forwarded to the Chief of Engineers U.S.A.
with annual report for the year ending June 30th 1881
W.H. Heuer
Captain of Engineers U.S.A.

Examinations & Surveys
South Pass Mississippi River
Captain W. H. Heuer, Corps of Engrs U.S.A.
in charge.

Chart No 3
of a part of

Gulf of Mexico

seaward from the ends of South Pass Jetties
to a depth of 100 feet.

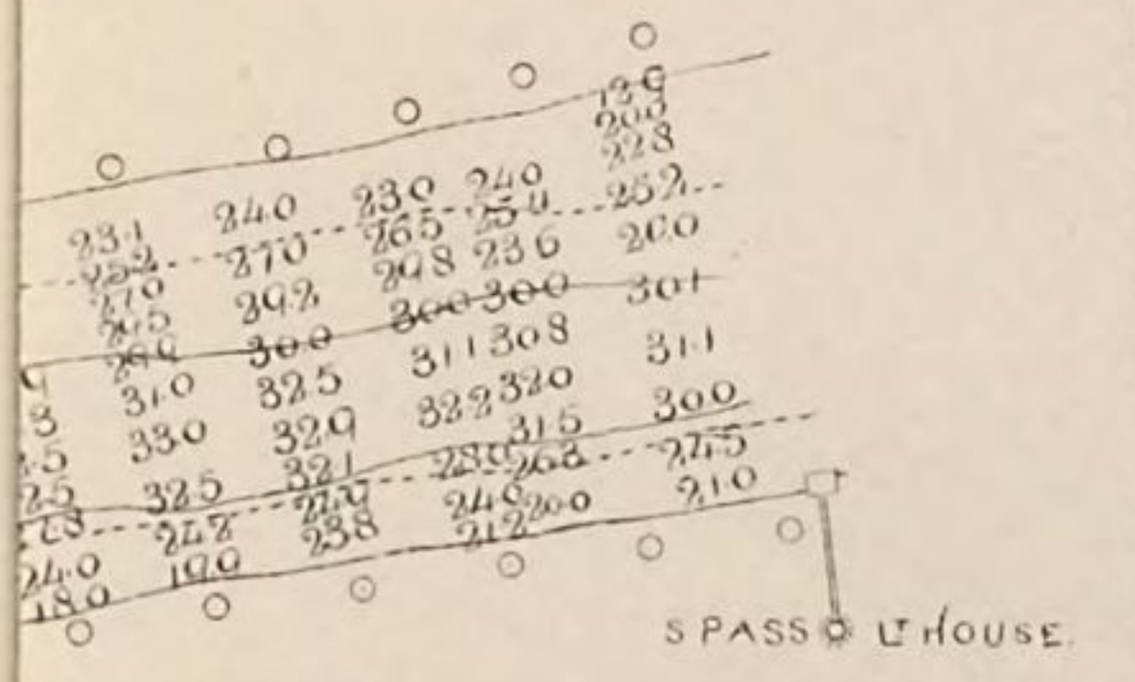
Surveyed and Plotted
BY
C. Donovan, Assistant Engineer
assisted
T. L. Raymond, Asst. Engr.

NOTE
Depths are expressed in feet and tenths of a foot and refer to the plane of Average Low Tide indicated by a reading of 2.0 feet on U.S. Engineers gauge at South Pass Light House.
Soundings taken June 11th 13th and 14th 1881

Contours.
20 — 30 — 40 — 50 — 60
70 — 80 — 90 — 100

New Orleans La. July 18th 1881
Forwarded to the Chief of Engineers U.S.A.
with annual report for the year ending June 30th 1881
W. H. Heuer
Captain of Engineers U.S.A.

EAST JETTY
WEST JETTY
EAST LUMP
TRUE MERIDIAN
Soale
Soundings



New Orleans La. July 18th 1881.

the Chief of Engineers U.S.A

for the year ending June 30th 1881.

W. H. Heuer.

Captain of Engineers U.S.A

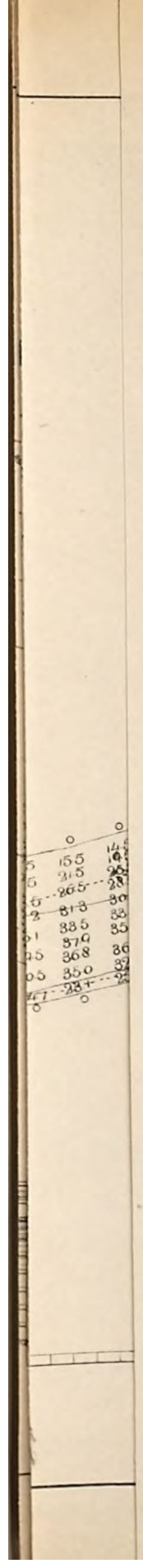


CHART No 6

HEAD OF PASSES

MISSISSIPPI RIVER,

Showing location of jetties, dykes, dams &c.

SURVEYED AND PLOTTED BY ORDER

OF

Capt. W.H.HEUER. Corps of Engr's, U.S.A.

BY

C Donovan, Assistant Engineer

ASSISTED BY

T L Raymond Ass't Engr.

MAIN LAND

MAIN LAND

UPPER DAM

DAM No 2

DAM No 3

DAM No 1.

DAM No 5

MATTRESS SILL

MATTRESS SILL

EAST PASS LIGHT

EAST LIGHT

HEAD OF PASSES LIGHT HOUSE

Shoal water — marsh, grass growing even to border of this small

Scale

NOTE

Depths are expressed in feet and tenths of a foot and refer to the plane of Average Flood Tide indicated by a reading of 4.50 feet on U.S. Engineers gauge at Head of Passes Light House.

Soundings taken June 6th & 7th and 9th 1881.

Carrollton gauge reading 12.80 feet.

New Orleans, La. July 18th 1881

Forwarded to the Chief of Engineers U.S.A.

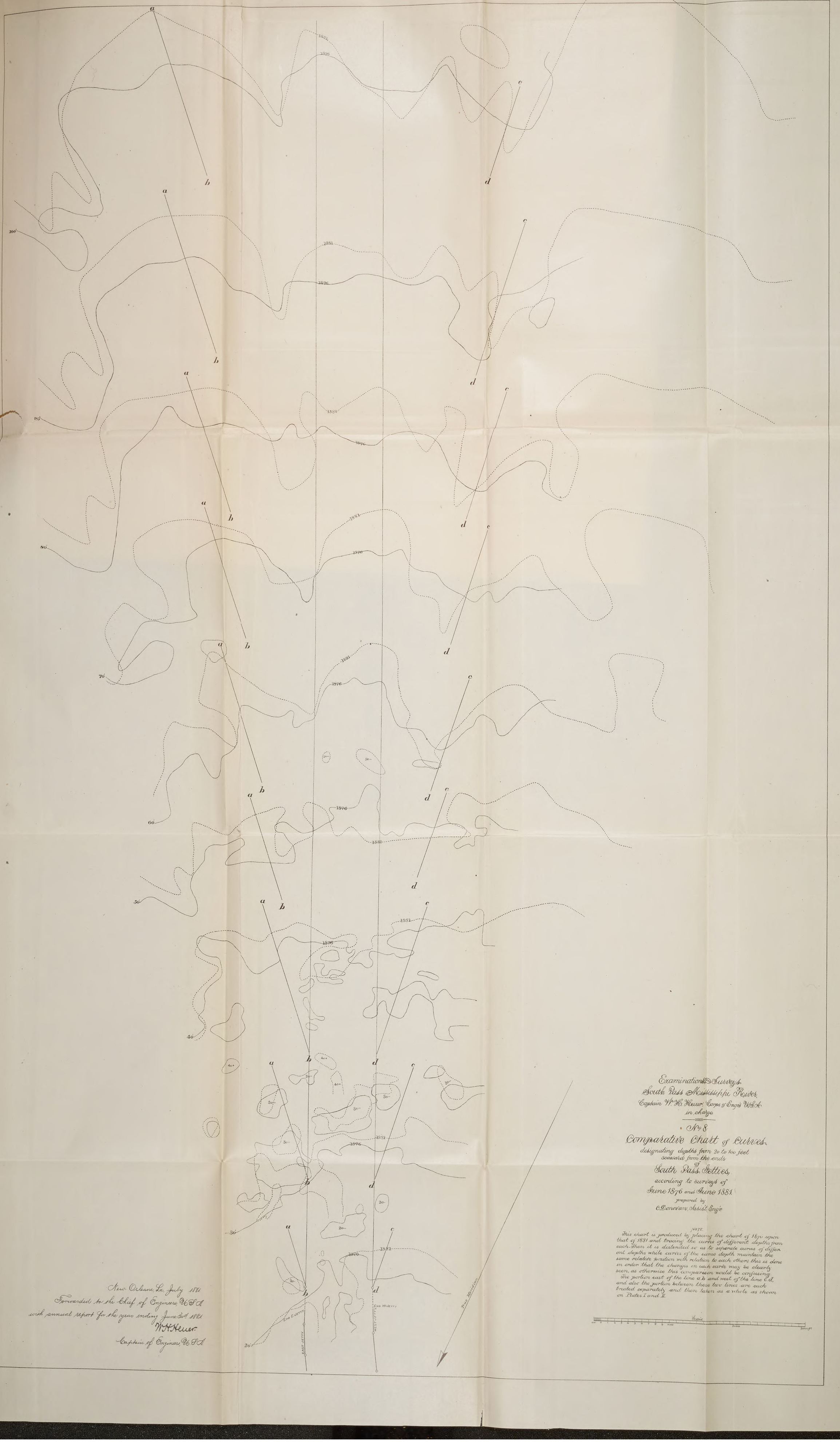
with annual report for the ending June 30th 1881

W.H.Heuer.

Captain of Engineers U.S.A.

2

E



New Orleans, La. July 1881
Forwarded to the Chief of Engineers, U.S.A.
with annual report for the year ending June 30th 1881.
W.H. Heuer.
Captain of Engineers, U.S.A.

Examinations & Surveys,
South Pass Mississippi River,
Captain W.H. Heuer, Corps of Engrs U.S.A.
in charge.

No 8

Comparative Chart of Curves

designating depths from 20 to 100 feet
seaward from the ends
of
South Pass Jetties,
according to surveys of
June 1876 and June 1881.

prepared by
C. Donovan, Assist. Engr.

NOTE.

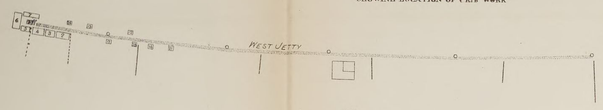
This chart is produced by placing the chart of 1876 upon that of 1881 and tracing the curves of different depths from each. Then it is distended so as to separate curves of different depths while curves of the same depth maintain the same relative position with relation to each other; this is done in order that the changes in each curve may be clearly seen, as otherwise this comparison would be confusing.

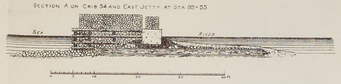
The portion east of the line a b and west of the line c d, and also the portion between these two lines are each treated separately and then taken as a whole as shown on Plates I and II.

PLAN OF

END OF JETTIES

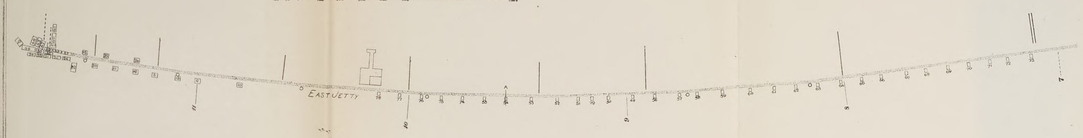
SHOWING LOCATION OF CRIB WORK

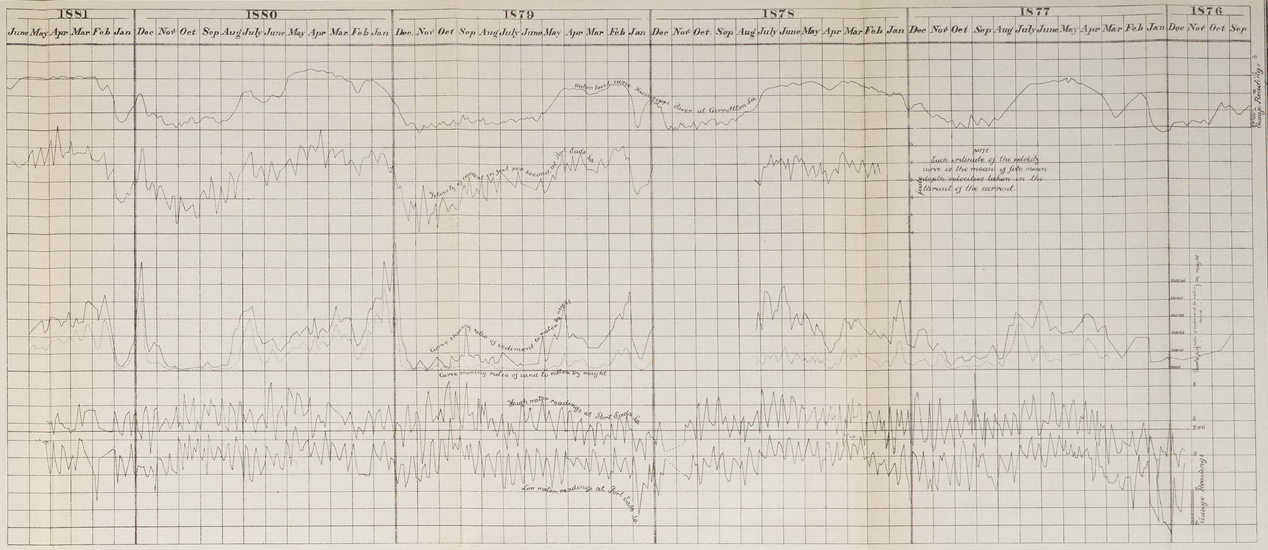




NOTE

This plan shows the location of all cribs in place July 1st 1881. Those placed during the year are numbered, from 60 to 81 inclusive. For dimensions see table in body of report.





COMPARATIVE PROFILES

OF

LINES A B, C D & E F

CHART Nº 6

From Coast Survey soundings June 1873 and soundings made June 1880 and 1881.

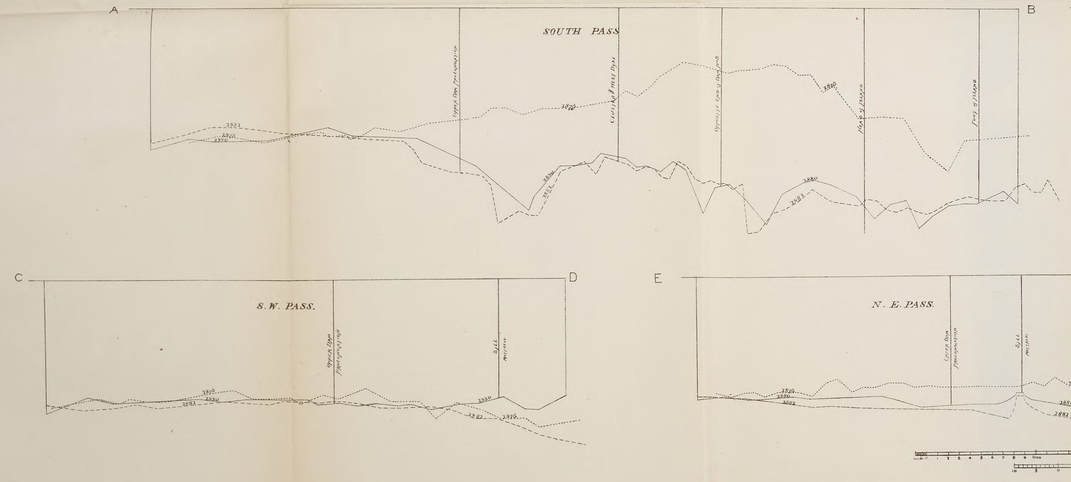


CHART Nº 9

TO ACCOMPANY THE

ANNUAL REPORT

UPON THE

IMPROVEMENT OF SOUTH PASS

OF THE

MISSISSIPPI RIVER.

BY

C DONOVAN, Asst. Engr.

COMPARATIVE SECTIONS

OF THE

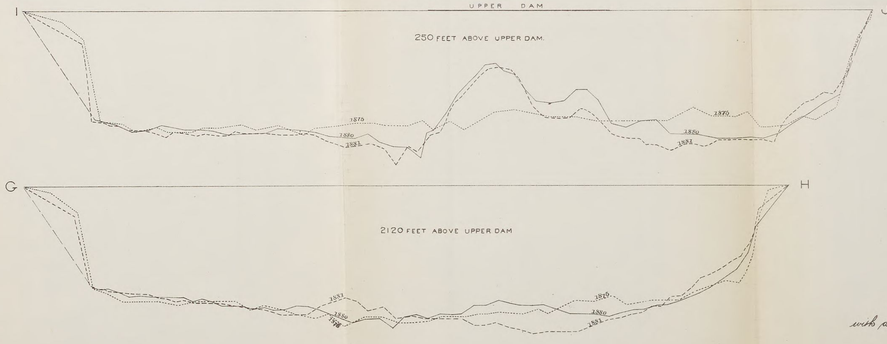
MISSISSIPPI RIVER

ON

LINES G H & I J

CHART Nº 8

From Coast Survey soundings June 1875 and soundings made June 1880 and 1881.



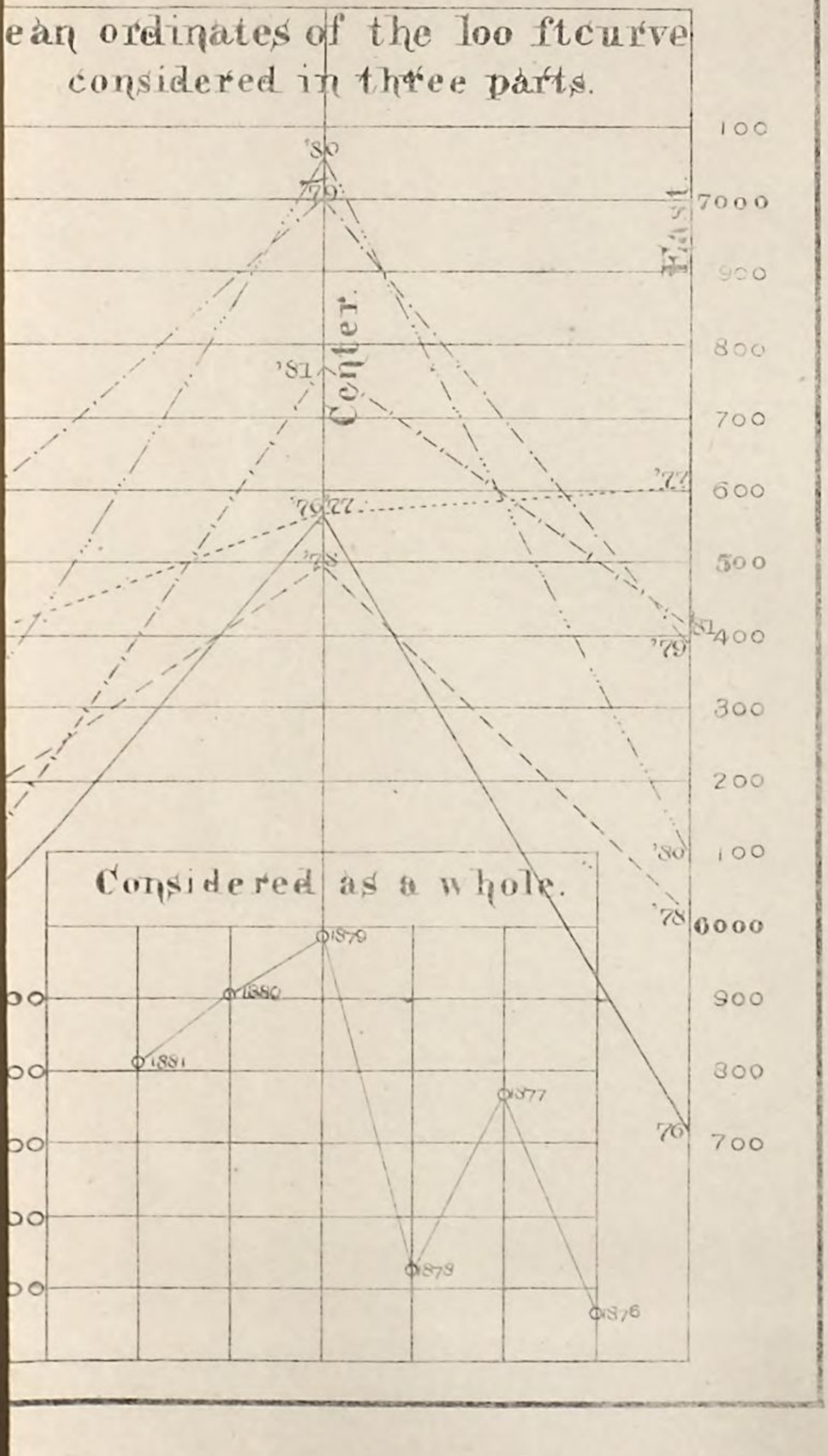
New Orleans La July 15th 1881

Forwarded to the Chief of Engineers U.S.A.

with annual report for the year ending June 30th 1881

M. A. Kellen

Captain of Engineers U.S.A.


Mean ordinates of the 100 ft curve considered in three parts.
'80
'79
'81
Center.
East.
'77
'79 '77
'78
'79
'80
'78
100
7000
900
800
700
600
500
400
300
200
100
6000
900
800
700
Considered as a whole.
1879
1880
1881
1877
1878
1876
70

Diagrams
Showing the advance or recession
of the
Curves of various depths
seaward from the ends of
South Pass Jetties
from 1876 to 1881
compiled by
C Donovan, Assist Engr

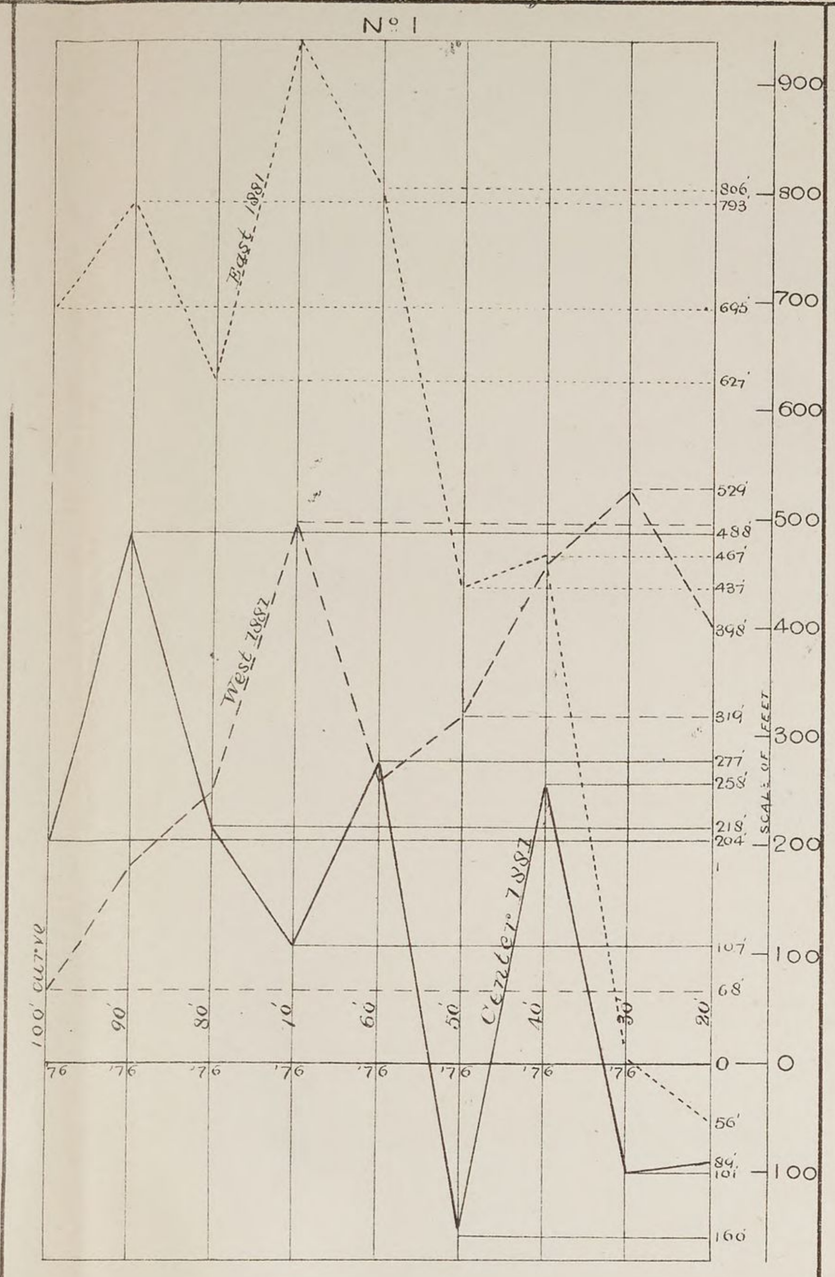
Note

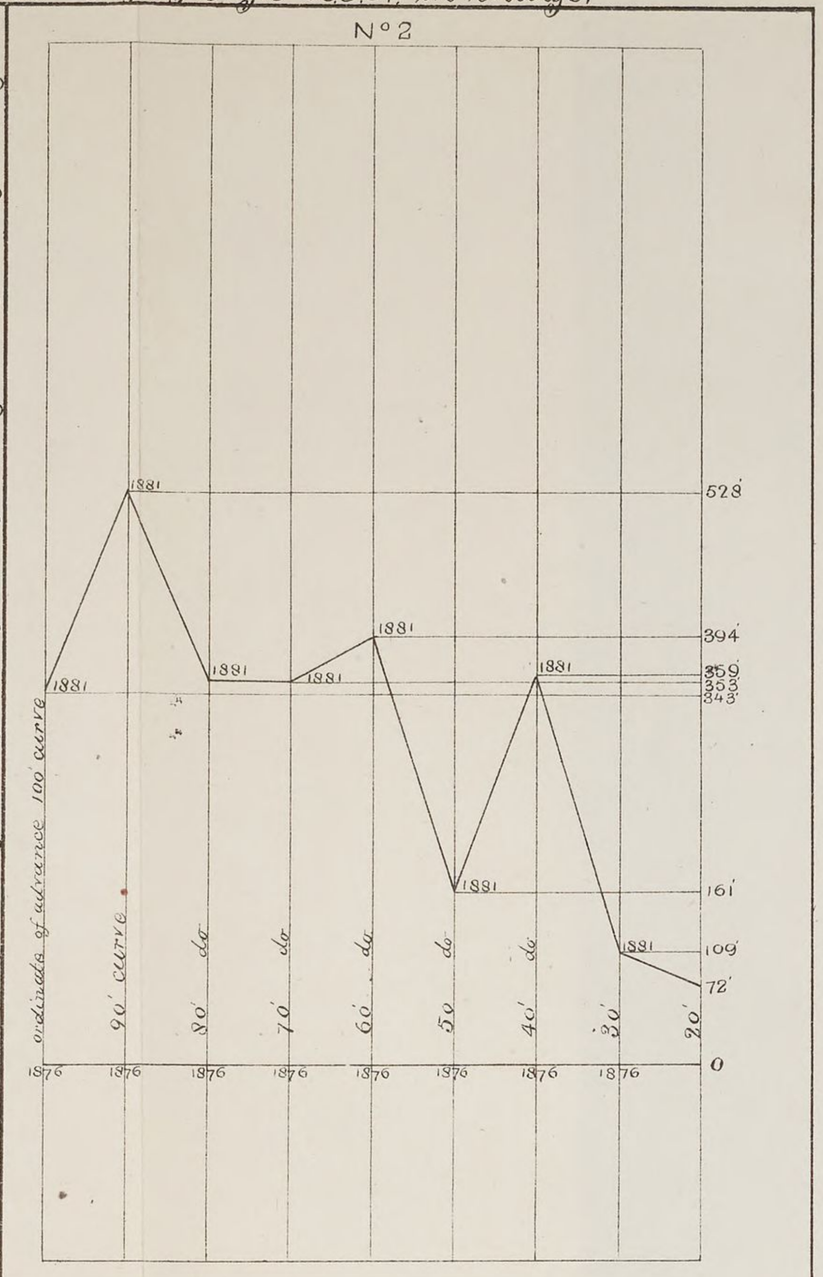
On these diagrams the length of each ordinate is the difference between the mean ordinate for 1876 and 1881 and therefore measures the amount of the movement of the various curves between these two dates, and for this purpose the ordinates of the positions of these curves in 1876 are assumed to be zero; negative ordinates indicate recession and positive ones advance of the curve to which they pertain

On №1 each curve is considered in three parts and we may see how each part is affected; the full line (—) joins the points representing the central portion of each curve the dotted line (.....) the eastern, and the broken line (- - -) the western portion On №2 each curve is considered as a whole

Each ordinate is marked with the number of the curve to which it pertains and the extremeties of each ordinate by the years between which the comparisons are made, and along the axis of ordinates is given (in feet) the distance that each curve has advanced or receded, so that at a glance we may note the change in each curve from 1876 to 1881 and also the amount of the same; for example, we see from №2 that from 1876 to 1881 the 100 feet curve advanced 343 feet, the 20 feet curve advanced 72 feet &c

These deductions are made from the same data as for Plate I.





APPENDIX M.

IMPROVEMENT OF HARBOR OF NEW ORLEANS; OF PEARL RIVER, MISSISSIPPI; OF BAYOUS TECHE AND BLACK, AND OTHER WATER-COURSES IN LOUISIANA; CONNECTION OF BAYOU TECHE WITH GRAND LAKE AT CHARENTON.

REPORT OF MAJOR C. W. HOWELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
New Orleans, La., August 17, 1881.

GENERAL: I have the honor to forward herewith the annual report for the fiscal year ending June 30, 1881, of the various works of river and harbor improvements under my charge.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

M 1.

IMPROVEMENT OF HARBOR AT NEW ORLEANS, LOUISIANA.

HISTORY.

This work originated from a survey made in the winter of 1877 and 1878, under the direction of a Board of Engineers convened at the request of the city authorities of New Orleans, to consider plans for the protection of the harbor front of New Orleans from the effects of caving banks of the Mississippi along that front (see Report of Chief of Engineers, 1878, volume 1, Appendix J 10).

The United States assumed charge of the work in 1878, and an appropriation of $50,000 was made for its commencement.

Under this appropriation work was begun and continued by hire of labor and purchase in open market until the appropriation was exhausted (see Reports of Chief of Engineers for 1879, Appendix K 1, and for 1880, Appendix M 1).

By act of Congress approved March 3, 1879, further appropriation was made to the amount of $60,000, and under this the work was put out at contract, John Roy being the contractor. The contract was entered into

December 26, 1879, and annulled February 10, 1881 (see Report of Chief of Engineers for 1880, and this report).

By act of Congress approved June 14, 1880, an appropriation of $75,000 was made for continuance of improvement. The contract under this appropriation was awarded to James E. Slaughter, and articles of agreement were entered into October 16, 1880 (see this report).

A further appropriation of $75,000 was made by act of Congress approved March 3, 1881.

WORK UNDER APPROPRIATION OF 1879.

The contract for this was entered into with John Roy, December 26, 1879 (see Report of Chief of Engineers for 1880, Appendix M 1, and this report).

The river having reached the stage designated in the contract as the proper one when laying of mats should be commenced, 7-foot stage on Carrollton gauge, the contractor was notified of this fact under date of August 9, 1880.

The articles of agreement relating to this point read as follows:

> It is further agreed between the said contracting parties that the said party of the second part shall have all his plant and material, and have made his arrangements to commence, and shall commence the laying of mats on or before the date at which the Mississippi River, after the flood of 1879 and 1880, shall have fallen to a stage represented on the Carrollton gauge as a 7-foot stage.

Owing to long delays in the actual work of commencing and conducting the laying of the mats, the season became so far advanced that the demands of commerce for wharves rendered it necessary to change the initial point from the foot of Mandeville street to a point 242 feet below the lower line of Montegut street. This change was made with the full concurrence of the contractor.

On the 21st September the driving of anchorage piles was commenced, and during the month 11 were driven. An attempt was made October 5 to sink a mat 140 feet by 200 feet, but failed. The first mat was launched October 9 (two months after the river had reached the proper stage for work). This mat was 70 feet by 200 feet. All the mats sunk after this date were of this size. Five of these mats were sunk during October, two during November, and three during December.

According to the report of the inspector, 12,059.64 square yards of the sloping river bank were covered in accordance with the terms of the contract, making the amount due contractor, after deducting 10 per cent. withheld until fulfillment of contract, $7,054.89. This differed materially from what was claimed by Mr. Roy, but as the inspector's estimate was based on the space covered by the mats in place on the sloping bank of the river bed, the total amount paid Mr. Roy was $7,054.89. The last payment (that for work done during December) was made January 7, 1881.

The device used in laying the mats consisted—

1. Of a large float made by fastening 8 coal barges together, and supporting launching ways calculated to accommodate a mat 140 feet by 200 feet.

The dimensions of the float over all were 170 feet by 206.8 feet.

The ways had a slope of $7\frac{1}{2}$ feet in 170 feet. After the failure to lay the large mat (October 5) the ways were changed so as to have dimensions suitable for a mat 70 feet or 84 feet by 200 feet, and their slope increased to $1 \div 8$.

2. The anchorage triangle made of flatboats' gunnels. This was right-

angled, the longest side being 281.5 feet, and the shortest 178 feet 10 inches.

In laying mats the triangle was moored so that one side was against the anchorage piles and the right angle down stream, the hypothenuse acting to deflect driftwood, &c.

Below the triangle at a proper distance was the ways' barge, having on it the mat ballasted for sinking. Ropes were attached to the up-stream edge of the mat, which were fastened to the down-stream side of the triangle; other ropes were attached to the down-stream edge of the mat, then the ways' barge was moved down stream so as to clear it of the mat, which was supposed to sink in its proper placed guided by the ropes attached to its up stream and down stream edges.

On the 19th of December, 1880, the triangle and ways' barge broke loose from their moorings and floated down the river in a broken-up condition, some of the material grounding at the passes. A large amount of driftwood had been collected by the triangle, and the pressure due to it is supposed to have parted the lines by which it was moored to the shore, when it moved down stream carrying with it the ways' barge.

The contractor having taken no steps towards renewing his plant or making any preparations looking to a resumption of work, and having written to this office a letter giving the impression that he had no hope of being able to continue, under date of January 25, 1881, it was recommended to the Chief of Engineers that his contract be annulled. This recommendation was approved under date of February 5, and under date of February 10 the contractor was notified that his contract stood annulled from that date.

When the contract with Mr. Roy was cancelled his sureties were notified that they could assume the work under the same articles of agreement. Two of them, Mr. F. A. Behan, and Mr. William H. Beanhain, gave notice in writing to this office of their intention to proceed with the contract, but the third one, Mr. F. E. Foucher, failed to give such notice, although addressed several times on the subject.

Since the two sureties assumed the contract the river has been at too high a stage for work, but this office has received notification of construction of plant and that laying of mats will be commenced as soon as the river has fallen so as to read 7 feet on the Carrollton guage. The point at which work will be commenced is at the foot of Mandeville street, in continuation of that done by hire of labor and purchase in open market in previous years.

WORK UNDER APPROPRIATION OF 1880.

The following project was submitted under date of July 8, 1880, for expenditure of appropriation of $75,000, authorized by act of Congress approved June 14, 1880.

It is proposed to apply this amount to the protection of that portion of the harbor front known as the "Carrollton Bend," and specified in report of Board of Engineers as section No. 1 of the harbor. This proposition is based on the following considerations:

1. The work provided for in the 3d District Bend, specified in report of Board as section No. 2, to which preceding appropriations have been devoted, now stands as follows:

The appropriation of 1878 has been exhausted and contract under appropriation of 1879 is only now about commencement, and owing to the very obstructed condition of this portion of the front (due to shipping in port and wrecked wharves), and to the possibility of delays on the part of the contractor, and possible failure, the work

may not be completed before the close of the favorable season. With the uncertainty existing it is considered undesirable to provide at present for further work on this section.

2. The Carrollton Bend (section 1), which was considered second in order of protection, and has been considered in danger for the past few years, now appears to require attention.

3. A fair test of the work, in its bearings on the general preservation of caving banks of the river, may be had in this section and cannot be had in the second section.

It is proposed to continue the details of the work as heretofore, viz, providing only for covering the steeper sloping portion of the river bed below the low-water line, and leaving the longitudinal bulk-head for future action, as it is now considered fairly probable that the latter would prove an unnecessary expense and may be added at any time if deemed desirable.

Specifications forwarded herewith will further explain the project.

It is proposed to let the work at contract, and if possible get it under way during the present low-water season.

This project and the specifications above referred to having been approved by the Chief of Engineers, advertisements inviting proposals were duly published in the proper newspapers, and the bids received opened August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving harbor at New Orleans, Louisiana.

No.	Names of bidders.	For covering per square yard of river bed.	Time of commencing work.
1	Robert McNamara	$0 97	September 15, 1880.
2	J. E. Slaughter	55	December 1, 1880.
3	John Kaiser, William Moylan	64	October 1, 1880.
4	W. H. Bell	71	20 days after date of contract.

James E. Slaughter being the lowest responsible bidder, the contract was awarded him, and articles of agreement duly entered into under date of October 16, 1880. The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Charles W. Howell, for and in behalf of the United States of America, and the said James E. Slaughter, for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other as follows, viz:

To manufacture, furnish, and place in proper position an artificial covering of cane mats over such sloping portion of the Mississippi River bed, near Carrollton, La., as may be designated by the said party of the first part in manner to conform to specifications and instructions from said party of the first part, but with such appliances as said party of the second part may select for his purpose.

It is further agreed that said party of the second part may drive his guide piles 6 feet apart from center to center instead of 7 feet apart as provided in specification. It is further agreed that said party of the second part shall commence his preparations for the work herein specified at once, and push the whole work to completion as rapidly as possible, the extreme limit of time allowed being as stated hereinafter.

For and in consideration of the said party of the second part faithfully complying with his agreement, the said party of the first part agrees to pay to the said party of the second part, his heirs, executors or administrators the sum of 55 cents per square yard for all said sloping portion of river bed as the said mats may be made to actually cover to the satisfaction of the said party of the first part, less on each partial payment the percentage specified hereinafter, which percentage is to be held until the whole work be completed and accepted.

It is further provided that the number of square yards covered by this contract shall not exceed 130,900 square yards, but must be fully that to within a margin of 100 square yards before final settlement can be made.

The contractor has given notice, through his agent, that he expects to commence work of laying mats in the fore part of August.

By act of Congress approved March 3, 1881, $75,000 was appropriated for continuation of the work. Project and specifications for application of this amount will be submitted in a short time.

The present contract with J. E. Slaughter is calculated to cover 5,890.5 linear feet along the river bank, commencing at a point 8,300 feet above the Carrollton gauge.

According to the Report of the Board of Engineers for this work (see Report of Chief of Engineers for 1878, Appendix J. 10), the length of the caving section in Carrollton Bend is 9,200 feet; so that, after the present contract has been carried out, there will still remain 3,309.5 feet of this section to be protected.

Examinations made recently show that slight caving is going on below what was considered the lower limit, when the original survey was made.

The intention at present is to use so much of the appropriation of 1881 as may be needed to continue the matting to the lower end of the caving section, and make use of the balance to strengthen and repair such portions of the entire work in the bend as may require it.

EFFECT OF MATS.

The work so far has not been continuous to an extent sufficient to warrant any statement for or against the success of the mats, in accomplishing the purpose for which they were intended, *i. e.*, protecting caving banks. It is expected that definite information will be obtained on this point from the Carrollton Bend work, where there are no wharves or shipping to interfere with laying the mats.

The amount recommended—$200,000—for the fiscal year ending June 30, 1883, is to be applied in continuing the work under the present project at such places designated by the Board of Engineers as may be determined on hereafter.

The work is in the collection district of New Orleans.

The nearest light-house is on the river at the head of the passes.

Total amount appropriated	$260,000 00
Total amount expended	61,524 55

Money statement.

July 1, 1880, amount available	$133,088 77	
Sale of public property	1,406 58	
Amount appropriated by act approved March 3, 1881	75,000 00	
		$209,495 35
Deposited	1,406 58	
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	9,467 30	
July 1, 1881, outstanding liabilities	146 02	
		11,019 90
July 1, 1881, amount available		198,475 45
Amount (estimated) required for completion of existing project		216,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		200,000 00

M 2.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, FROM JACKSON TO CARTHAGE.

This work originated from an examination which was provided for by Congress in the river and harbor act of 1878, report of which will be found in the Annual Report of the Chief of Engineers for 1879, Appendix K 2.

In the river and harbor act approved March 3, 1879, appropriation of $6,000 was made for commencing the work, and under date of November 20, 1879, contract was entered into with J. S. Hamilton & Co. to do the work as specified. Owing to high-water but little work under this contract was done during the fiscal year ending June 30, 1880, and it was not until March 14, 1881, that the contractors reported the work completed. Assistant Engineer H. C. Collins was at once ordered to make the necessary inspection before settlement could be effected, and reported that much remained to be done to make the work conform to the requirements of the agreement. The contractors were duly notified of this fact.

By act of Congress approved June 14, 1880, $7,500 was appropriated for continuing this work.

The specifications having been approved by the Chief of Engineers, and the work having been duly advertised under them, bids were received and opened on August 30, 1880. The following is an abstract of the bids received:

Abstract of proposals received for improving Pearl River, Mississippi, from Jackson to Carthage.

No.	Names of bidders.	For removal of obstructions as specified.	Time of commencing work.
1	F. B. Hull, W. S. Hull	32 miles, $7,000, commencing at railroad bridge at Jackson, Miss.	Not stated.
2	J. S. Hamilton.	51 miles, $7,000.	Immediately upon notification of acceptance of propositions.

J. S. Hamilton being the lowest responsible bidder, the contract was awarded to him, and articles of agreement duly entered into under date of October 12, 1880, and approved under date of November 2, 1880.

The following is the body of the agreement:

This agreement witnesseth, that in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Maj. Charles W. Howell for and in behalf of the United States of America, and the said Jones S. Hamilton for himself, his heirs, executors and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz: That the said party of the second part in accordance with his proposal hereunto attached, and the advertisement and specifications above referred to, shall faithfully perform the work of improving the navigation of Pearl River, Mississippi, for a continuous distance of 51 miles up stream from the railroad bridge at Jackson, Mississippi, in every particular as specified.

That the said party of the first part, in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance, agrees to pay to the latter the sum of $7,000.

Since this agreement was entered into the river has been too high at nearly all times for advantageous work, and the contractor has as yet failed to report any progress.

In the river and harbor act approved March 3, 1881, there was further provision made for this work to the amount of $2,500.

The following project for expenditure of this amount has been submitted and approved, namely:

PROJECT.

It is proposed to continue the improvement of this river in accordance with the project submitted July 8, 1880, and approved by the Chief of Engineers under date of July 16, 1880.

The contract for this work now in force under appropriation in river and harbor act approved June 14, 1880, covers 51 miles of river up stream from the railroad bridge at Jackson; and it is proposed to commence work under the present appropriation at the upper limit of this section and continue it up stream as far as the amount available will permit, work to be done by contract and award to be based on the amount per mile for which it is proposed to make the improvement.

Specifications drawn in accordance with the above project have also been submitted and approved.

The work is located in the State of Mississippi and the nearest light-house is on the Rigolets, opposite the mouth of West Pearl River.

The work is not considered permanent, because it appears quite certain that the channel opened will gradually fill, in places, with drift, &c.

To complete the improvement of this river under the present project an additional appropriation of $5,000, is recommended for the fiscal year ending June 30, 1883.

Original estimated cost	$21,000 00
Total amount appropriated	16,000 00
Total amount expended	415 14

Money statement.

July 1, 1880, amount available	$13,286 97	
Amount appropriated by act approved March 3, 1881	2,500 00	
		$15,786 97
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		202 11
July 1, 1881, amount available		15,584 86
Amount (estimated) required for completion of existing project		5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		5,000 00

M 3.

IMPROVEMENT OF PEARL RIVER, BELOW JACKSON, MISSISSIPPI.

This work originated in an examination authorized by act of Congress approved June 18, 1878, a report of which, together with plan and estimate, was published in Report of the Chief of Engineers for 1879, Appendix K 2.

By act of Congress approved June 14, 1880, the sum of $30,000 was appropriated for its commencement.

A project for this work having been submitted and approved (Report of Chief of Engineers, 1880, Appendix M 3), specifications were prepared, and after their approval, and after the work had been duly advertised under them, bids were received and opened on August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving Pearl River, Mississippi, below Jackson, Mississippi.

No.	Bidders.	For removal of obstructions as specified.
1	S. N. Kimball	195 miles, $28,736.
2	H. A. Peeler & F. D. Waldsaur	118 miles, $28,750.
3	G. A. Meyer	180 miles, $28,750.
4	Jones S. Hamilton	191 miles, $28,750.
5	W. S. Hull, B. Hull	131 miles, $28,750.
6	A. L. Gervin	$1,400 per mile.

Seth N. Kimball being the lowest responsible bidder, the contract was awarded him, and articles of agreement duly entered into under date of October 7, 1880, and approved under date of November 15, 1880.

The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Charles W. Howell for and in behalf of the United States of America, and the said Seth N. Kimball for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other as follows, viz:

That the said party of the second part, in accordance with advertisement and specifications above referred to and in accordance with his proposal herewith attached (subject to proviso herein), shall faithfully perform the work of improving the navigation of Pearl River, Mississippi, from the railroad bridge at Jackson, Mississippi, for a continuous distance down said Pearl River of 195 miles, or, in other words, to a point on said stream about three-fourths of a mile below "Harrison's Ferry," as exhibited on a chart on file in the United States Engineer office at New Orleans, Louisiana.

That the said party of the first part, for and in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance as provided for, agrees to pay to the latter the sum of $28,736.

That it is mutually agreed and declared by the contracting parties that the subdivisions of the work, the calculations and permileages specified in the body of the bidder's proposal above referred to, are null and void, and that this agreement is based solely on the "lump" bid and printed specifications.

Owing to high-water but little progress has been made, although the contractor reports his plant as ready, and all arrangements made to commence work as soon as the river shall be at the proper stage. By act of Congress approved March 3, 1881, further provision was made for this work to the amount of $25,000, and the following project for its expenditure has been submitted and approved:

PROJECT.

It is proposed to continue the improvement of this river, in accordance with the project submitted July 8, 1880, and approved by the Chief of Engineers under date of July 16, 1880. The contract for this work now in force under appropriation in river and harbor bill approved June 14, 1880, covers 195 miles of river down stream from the railroad bridge at Jackson, and it is proposed to commence work under the present appropriation at the lower limit of this section, and continue it down stream as far as the amount available will permit. Work to be done by contract, and award to be based on the amount per mile for which it is proposed to make the improvement.

Specifications drawn in accordance with the above project have been submitted and approved. The original estimate for this work was $95,940, or $40,940 more than has been appropriated, and it is therefore recommended, for the continuance of the work under the present project, that an additional appropriation of $40,940 be made for the fiscal year ending June 30, 1883.

The work is not considered of a permanent character, as obstructions caused by trees falling into the river, drift logs, and snags are liable to occur at any time. The work is located in the collection district of New

Orleans, and the nearest light-house is at the Rigolets, opposite mouth of West Pearl River.

The commercial importance of the work was set forth in report of examination.

Total estimated cost	$95,940 00
Total amount appropriated	55,000 00
Total amount expended	1,192 20

Money statement.

July 1, 1880, amount available	$30,000 00	
Amount appropriated by act approved March 3, 1881	25,00000	
		$55,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	956 87	
July 1, 1881, outstanding liabilities	235 33	
		1,192 20
July 1, 1881, amount available		53,807 80
Amount (estimated) required for completion of existing project		40,940 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		40,940 00

M 4.

IMPROVEMENT OF AMITE RIVER, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was printed in House Ex. Doc. No. 54, Forty-sixth Congress, second session. By act of Congress approved June 14, 1880, $8,000 was appropriated for its commencement.

A project for the expenditure of this amount was submitted to the Chief of Engineers and by him approved (Report of Chief of Engineers, 1880, Appendix M 5).

Specifications drawn in accordance with the project were submitted and approved, and after the work had been duly advertised bids were received and opened August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving Amite River, Louisiana.

No.	Bidders.	For removal of obstructions as specified.
1	R. E. Davidson for Davidson & Malarich	40 miles, $7,650
2	M. B. Muncy	7,650
3	H. E. Glasscock	40 miles, 7,650

Haden E. Glasscock being the lowest responsible bidder, the contract was awarded him, and articles of agreement duly entered into under date of October 4, 1880.

The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached and which form a part of this contract, the said Maj. Charles

W. Howell, for and in behalf of the United States of America, and the said Haden E. Glasscock for himself, his heirs, executors, and administrators, have mutually agreed and by these presents do mutually covenant and agree, to and with each other as follows, viz:

That the said party of the second part, in accordance with his proposal hereunto attached, and the advertisement and specification above referred to, shall faithfully perform the work of improving the navigation of Amite River, Louisiana, for a continuous distance of 40 miles up stream from its junction with the Bayou Manchac in every particular as specified; that the said party of the first part, in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance, agrees to pay to the latter the sum of $7,650.

At the time agreement was entered into the river was at too high a stage for commencement of work, and it was not until May, 1881, that the contractor commenced operations, since which time 6½ miles of river have been reported by the contractor as completed, leaving 33½ miles to be cleared.

By act of Congress approved March 3, 1881, further provision was made for this work to the amount of $5,000, and under date of April 30, 1881, a project for continuing the work was submitted to the Chief of Engineers and approved May 12, 1881.

The following is the project:

It is proposed to continue the improvement of this river in accordance with the project submitted July 8, 1880, and approved by the Chief of Engineers under date of July 16, 1880.

The contract for this work now in force under appropriation in river and harbor act approved June 14, 1880, covers 40 miles of river up stream from its junction with Bayou Manchac, and it is proposed to commence work under the present appropriation at the upper limit of this section and continue it as far as the amount available will permit; work to be done by contract, and award to be based on the amount per mile for which it is proposed to make the improvement.

Specifications drawn in accordance with this project have been submitted and approved.

The original estimate for this work was $23,760, or $10,760 more than the amount appropriated, and it is therefore recommended, for continuance of the work, that an appropriation of $10,760 be made for the fiscal year ending June 30, 1883.

The commercial importance of the work was indicated in report of examination.

The improvement is not considered a permanent one, as the obstructions caused by trees falling into the river, drift logs, and snags are liable to re-form at any time.

The work is located in the collection district of New Orleans, and the nearest lighthouse is at the mouth of Pass Manchac.

Original estimated cost	$23,760 00
Total amount appropriated	13,000 00
Total amount expended	154 27

Money statement.

July 1, 1880, amount available	$8,000 00	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$13,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		154 27
July 1, 1881, amount available		12,845 73
Amount (estimated) required for completion of existing project		10,760 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,760 00

M 5.

IMPROVEMENT OF VERMILLION RIVER, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was printed in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $5,000 was made for commencement of the work. A project for expenditure of this amount was published in Report of Chief of Engineers for 1880, Appendix M 6.

Specifications drawn in accordance with the project were submitted to the Chief of Engineers and by him approved, and the work duly advertised. At the time for opening proposals (August 30, 1880), none had been received.

Under date of December 7, 1880, G. A. Meyer made a proposition to clear 22 miles of river, down stream, from the railroad bridge, for $4,750

This proposition having been submitted to the Chief of Engineers, and approved, articles of agreement were duly entered into under date of February 18, 1881. The following is the body of the agreement:

> This agreement witnesseth that, in conformity with the specifications hereunto attached, and which form a part of this contract, the said Major Charles W. Howell, for and in behalf of the United States of America, and the said Gustavus A. Meyer, for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz:
>
> That the said party of the second part, in accordance with his proposal hereunto attached, and the specifications above referred to, shall faithfully perform the work of improving the navigation of Vermillion River, La., for a distance of 22 miles (continuously down stream), beginning at the railroad bridge, in every particular as specified.
>
> That the said party of the first part, in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance, agrees to pay to the latter the sum of $4,750.

At the time agreement was entered into the river was at too high a stage for commencement of work.

The contractor states that he will be able to commence work on or about July 1, 1881.

By act of Congress approved March 3, 1881, an additional appropriation of $4,900 was made for completing improvement.

A project for expenditure of this amount was submitted to the Chief of Engineers under date of April 30, 1881, and by him approved under date of May 12, 1881.

The project provides for closing the eastern entrance, at its mouth, by a low-water dam, and applying the balance that may remain to clearing the banks of overhanging trees, and the bed of the river of all trees, logs, and snags that may be found in it, commencing at the lower limit of the section now under contract and proceeding down stream.

The commercial importance of the work was indicated in the report of examination.

The work is located in the collection district of New Orleans, and the nearest lighthouse is at the entrance of Atchafalaya Bay.

Original estimated cost	$9,900 00
Total amount appropriated	9,900 00
Total amount expended	113 54

Money statement.

July 1, 1880, amount available	$5,000 00	
Amount appropriated by act approved March 3, 1881	4,900 00	
		$9,900 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		113 54
July 1, 1881, amount available		9,786 46

M 6.

IMPROVEMENT OF TANGIPAHOA RIVER, LOUISIANA.

This work originated in an examination authorized by act of Congress approved June 18, 1878, a report of which, together with plan and estimate for improvement, was published in Report of Chief of Engineers for 1879, Appendix K 14.

By act of Congress approved June 14, 1880, an appropriation of $5,000 was made for its commencement, and a project for its application submitted and approved. (Report of Chief of Engineers, 1880, Appendix M 4.)

Specifications were drawn in accordance with the project; and after approval and after the work had been duly advertised under them, bids were received and opened on August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving Tangipahoa River, Louisiana.

No.	Bidders.	For removal of obstructions as specified.
1	C. P. Seymer	34 miles from mouth, $4,750.
2	Alfred Bradley	Mouth to junction of Chappupela Creek, $4,750.
3	William Wells, Henry Elleman, C. A. Eager	27 miles, $4,750.
4	E. P. Doherty	45 miles.

Carl P. Seymer being the lowest responsible bidder, the contract was awarded him, and articles of agreement duly entered into under date of September 22, 1880, and approved under date of September 30, 1880.

The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached and which form part of this contract, the said Major Charles W. Howell, for, and in behalf of the United States of America, and the said Carl P. Seymer for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz:

That the said party of the second part, in accordance with his proposal hereunto attached and the advertisement and specifications above referred to, shall faithfully perform the work of improving the navigation of Tangipahoa River, Louisiana, for a continuous distance of 34 miles up stream from its mouth, in every particular as specified.

That the said party of the first part, in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance, agrees to pay to the latter the sum of $4,750.

Owing to high-water work was not commenced by the contractor until May 2, 1881, and up to June 30, 1881, 6½ miles are reported as having been completed:

By act of Congress, approved March 3, 1881, further provision for this work was made to the amount of $2,000, and the following project for its application has been submitted and approved:

PROJECT.

It is proposed to continue the improvement of the river in accordance with the project submitted July 8, 1880, and approved by the Chief of Engineers under date of July 16, 1880.

The contract for this work now in force, under appropriation in river and harbor act, approved June 14, 1880, covers 34 miles of river up stream from its mouth, and it is proposed to commence work under the present appropriation at the upper limit of this section, and continue it as far as the amount available will permit, work to be done by contract and award to be based on the amount per mile for which it is proposed to make the improvement.

Specifications drawn in accordance with the above project have been submitted and approved.

The work is not considered permanent because the obstructions caused by drift, trees, logs, and snags are liable to reform.

The commercial importance of the work was indicated in report of examination.

The original estimate of cost of improvement was $10,700; the amount appropriated is $7,000; and it is recommended that $3,700 be appropriated for the fiscal year ending June 30, 1883.

The work is situated in the collection district of New Orleans. The nearest lighthouse is at the mouth of Pass Manchac.

Total estimated cost	$10,700 00
Total amount appropriated	7,000 00
Total amount expended	156 09

Money statement.

July 1, 1880, amount available	$5,000 00	
Amount appropriated by act approved March 3, 1881	2,000 00	
		$7,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		156 09
July 1, 1881, amount available		6,843 91
Amount (estimated) required for completion of existing project		3,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		3,700 00

M 7.

IMPROVEMENT OF TCHEFUNCTE RIVER, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate, was published in report of Chief of Engineers for 1880, Appendix M.

By act of Congress approved March 3, 1881, an appropriation of $1,500 was made for its commencement, and, under date of April 30, 1881, a project for improvement was submitted to the Chief of Engineers.

PROJECT.

The entrance of the river from Lake Pontchartrain is good, requiring no improvement to admit any vessels likely to be needed for its commerce. Ascending the river,

a broad and deep channel is found from the mouth to "The Old Landing," a distance of 12¼ miles.

This point is 2 miles in a direct line, or 3 miles by river from Covington. Assistant Engineer Hoffman, who made an examination of this stream in 1880, reported the river between "The Old Landing" and Covington as very much obstructed by snags and overhanging trees, and that the channel was very crooked with sharp bends.

It is proposed to apply the appropriation to clearing this section of overhanging trees and snags, the work to be done by contract, after advertisement, and award to be based on the amount per mile for which it is proposed to make the improvement.

This project was approved under date of May 12, 1881.

Specifications, drawn in accordance with the project, having been submitted to the Chief of Engineers and by him approved, advertisements inviting proposals were published in the proper papers June 30, 1881.

Bids will be opened July 30, 1881.

The work is not considered of a permanent character, as the obstructions caused by snags, sunken logs, fallen and overhanging trees, are liable to re-form at any time.

The commercial importance of the improvement was indicated in the report of examination.

The work is located in the collection district of New Orleans. The nearest lighthouse is near Madisonville on the river.

Original estimate	$5,460 00
Total amount appropriated	1,500 00

Money statement.

Amount appropriated by act approved March 3, 1881	$1,500 00
July 1, 1881, amount available	1,500 00
Amount (estimated) required for completion of existing project	3,960 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	3,960 00

M 8.

IMPROVEMENT OF TICKFAW RIVER, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate, was published in Report of Chief of Engineers for 1880, Appendix M.

By act of Congress approved March 3, 1881, an appropriation of $2,000 was made for its commencement.

Under date of April 30, 1881, a project for this work was submitted to the Chief of Engineers.

PROJECT.

It is proposed to improve this river for navigation by removing from its bed all trees, logs, and snags to a depth of 7 feet below low-tide, or to the bottom of the river, where such depth does not obtain; also, to remove from the banks all overhanging trees. All trees, logs, and snags removed to be placed on the banks above high-water, or so disposed of as not again to become obstructions to navigation.

The work of improvement to commence at the mouth of the river, to be continuous, and to be done by contract; award to be based on the amount per mile for which it is proposed to make the improvement.

This project was approved by the Chief of Engineers under date of May 12, 1881. Specifications drawn in accordance with the project, having also been submitted to the Chief of Engineers, and having been ap-

proved by him, advertisements inviting proposals were published in the proper papers June 30, 1881.

Bids will be opened July 30, 1881.

The improvement is not considered a permanent one, as the obstructions are liable to re-form at any time.

The commercial importance of the river was indicated in the report of examination.

To complete the work according to original plan an additional appropriation of $8,230 for fiscal year ending June 30, 1883, is recommended.

The work is located in the collection district of New Orleans. The nearest lighthouse is at the mouth of Pass Manchac, between Lakes Maurepas and Pontchartrain.

Original estimate	$10,230 00
Total amount appropriated	2,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$2,000 00
July 1, 1881, amount available	2,000 00
Amount (estimated) required for completion of existing project	8,230 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	8,230 00

M 9.

IMPROVEMENT OF BAYOU TECHE, FROM SAINT MARTINSVILLE TO PORT BARRE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in Report of Chief of Engineers for 1880, Appendix M.

By act of Congress approved June 14, 1880, an appropriation of $6,000 was made for its commencement. A project for expenditure of this amount was submitted to the Chief of Engineers. (See Report of Chief of Engineers for 1880, Appendix M 8.)

After its approval, and after specifications drawn in accordance with it had been submitted and approved, the work was duly advertised and bids received and opened August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving Bayou Teche, from Saint Martinsville to Port Barre, Louisiana.

No.	Bidders.	For removal of obstructions as specified.	Time of commencing work.
1	G. A. Meyer	From Saint Martinsville to Leon's Bridge, Louisiana, $5,675.	To commence as soon as contract may be closed, unless prevented by high-water.

The bid of G. A. Meyer (the only one received), being considered a reasonable one, was accepted, and articles of agreement duly entered into under date of September 20, 1880, and approved under date of October 26, 1880.

The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Major C. W. Howell, for and in behalf of the United States of America, and the said Gustavus A. Meyer, for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz:

That the said party of the second part, in accordance with his proposal hereunto attached, and the advertisement and specification above referred to, shall faithfully perform the work of improving the navigation of Bayou Teche, La., from the town of Saint Martinsville to Leon's Bridge, in every particular as specified. That the said party of the first part, in consideration of the faithful performance of this specified work by the said party of the second part, and after its due acceptance, agrees to pay to the latter the sum of $5,675.

Owing to high-water at the time agreement was entered into, work was not commenced until October 24, 1880, and it was not until the end of June, 1881, that the contractor reported the work as completed.

An inspection was made by the assistant engineer who made the original examination, and his report being to the effect that the articles of agreement had been faithfully complied with, settlement was made with the contractor.

By act of Congress approved March 3, 1881, further provision was made for the improvement of this bayou by an appropriation of $20,000, and under date of April 30, 1881, a project for its application was submitted to the Chief of Engineers, and by him approved under date of May 12, 1881.

PROJECT.

Before submitting a detailed project for this work which will include exact location and general and detailed plans for a lock and dam, it is considered necessary to make an exact instrumental survey from Saint Martinsville to Port Barre, and this constitutes this preliminary project.

The survey will include transit and level lines, soundings and plottings on a working scale, and the preparation of plans will cover details and estimates for which data now at hand is not sufficient. The examination of 1880 was but a reconnaissance without instrumental work.

It is proposed for the survey to place on the duty the same party as last year provided for the Courtableau, at same rate of wages, except for principal assistant (now at $200 per month), and to keep total expense within $2,500.

It is expected that the survey will be commenced and completed during the present low-water season.

The commercial importance of this work was indicated in the report of examination.

The work is located in the collection district of New Orleans. The nearest lighthouse is at the entrance to Atchafalaya Bay.

Original estimated cost	$56,690 00
Total amount appropriated	26,000 00
Total amount expended	5,867 34

Money statement.

July 1, 1880, amount available	$6,000 00	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$26,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	164 84	
July 1, 1881, outstanding liabilities	5,702 50	
		5,867 34
July 1, 1881, amount available		20,132 66
Amount (estimated) required for completion of existing project		30,690 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		30,690 00

M 10.

IMPROVEMENT OF BAYOU TECHE, LOUISIANA, BY CONNECTING SAME WITH GRAND LAKE, AT CHARENTON, LOUISIANA.

An examination of the proposed line of this canal was made by Assistant Engineer H. C. Collins in 1879. (See Report of Chief of Engineers for 1880, Appendix M.)

By act of Congress approved March 3, 1881, an appropriation o $25,000 was made for commencement.

The site selected for the canal is along the upper end of the Mossy Tract Plantation, now owned by the Citizens' Bank of New Orleans.

The following explanatory statement and project were submitted to the department, under date of April 30, 1881:

The original estimate (which was only considered a rough approximation) of total cost of the work was $73,196.40. In this estimate excavation was sufficiently exact, but estimate for lock was made without having detailed plans to work from (nor have such as yet been drawn), while no allowance was made for revetment of lake end of canal, nor for purchase of land. The former was overlooked at the time, and as to the latter it was understood that the land required (about 67 acres) would be donated. In regard to the latter item, it was understood at the time of examination that the owners of the land (the Citizens' Bank of New Orleans) would no doubt donate, as the embankment of the canal would protect the balance of their plantation from overflow and greatly enhance its value otherwise. Before preparing project, I thought it proper to obtain positive assurance about right of way, and wrote to the president of the bank requesting official and definite information. The board of directors met yesterday and decided to sell to the United States, but I have not learned if a price was fixed. It is thought that the price should not exceed $15 per acre; otherwise resort should be had to expropriation.

It is therefore proposed, before taking any other steps, to secure the land needed; next to put out at contract the excavation and embankment of trunk of canal as hereafter described, and at the same time to commence preparation of detailed plans, &c., for lock and lake end revetment; next to construct the lock under future appropriations, and lastly to complete lake end of canal, which will extend 1,000 feet into the open lake, as the Bayou Saint John and New Canal at New Orleans do into Lake Pontchartrain.

PROJECT UNDER EXISTING APPROPRIATION.

Excavation and embankment alone, all of which can be done by a dredge-boat. Total amount to be applied for this, $22,500; $2,500 being retained for engineering, office, pro rata, &c.

1. A cut to be made from the lake to its shore line sufficient to admit a first-class dredge-boat, the excavated material to be placed on the east side, and as far from the east edge of cut as the dredge can throw it.

2. From the shore line toward the Teche, the excavation to be made full width, and embankments on both sides to full height so far as the money will permit.

The dimensions proposed for this are as follows: Depth of cut, 5 feet ordinary low-tide in lake; width at bottom, 50 feet; slope, 1 on 2; berme on both sides, 15 feet; height of embankment, high-water of 1874; least width on top, 10 feet; base for that width, 50 feet.

Other widths at top and base, and other heights, above least, to suit amount of material excavated.

The amount appropriated, at 20 cents per cubic yard, will half complete the trunk of canal.

I inclose tracing of plot of examination and profiles.

It will be observed that the line for which estimate has been made is a little to the eastward of the line of location proposed (which is along the east side of the upper line); but this makes no important difference, as the slopes were apparently the same. The lower line was taken for the levels, because it was clear of brushes that obstructed a part of the upper line, and so save time and expense, while giving equally applicable results.

In support of this proposition to excavate trunk of canal before commencing lock, I present the following:

1. If the trunk be completed, or partly completed, it will be of use with a short portage over the passable ground adjoining Bayou Teche. There is an instance of this in

the Mexican Gulf Canal, from Lake Borgne to near the Mississippi River, at the English Turn.

Supplies can be carried over cheaper than they can be taken 80 miles around, whereas if the lock be undertaken first, it can be of no use until connected with the lake and the Teche.

Should appropriations fail in future, partly completed works of no benefit would possibly be looked upon as a waste of money.

This project was approved by the Chief of Engineers, under date of May 20, 1880, and instructions given in it and department letter of June 2 with regard to the steps necessary to be taken to obtain proper title on the part of the United States to the land. These instructions will be carried out as soon as practicable.

The commercial importance of the work was indicated in the report of examination.

To continue the work an appropriation of $50,000 is recommended for the fiscal year ending 1883.

The work is situated in the collection district of New Orleans. The nearest lighthouse is at entrance to Atchafalaya Bay.

Total amount appropriated $25,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$25,000 00
July 1, 1881, amount available	25,000 00
Amount (estimated) required for completion of existing project, about	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	50,000 00

M 11.

IMPROVEMENT OF BAYOU BLACK, LOUISIANA.

The examination of this bayou was provided for in river and harbor act approved June 14, 1880.

Under date of February 2, 1881, a preliminary report of an examination by A. Jolet, jr., was forwarded to the Chief of Engineers. (See Senate Ex. Doc., No. 57, Forty-sixth Congress, third session.)

As Mr. Jolet persistently failed to furnish this office with a chart of the examination, or a detailed report, on which estimates could be based, despite the fact that he was frequently directed to do so, Assistant-Engineer H. S. Douglas, of this office, was directed to make a thorough examination of the bayou, and his report is hereto appended.

As will be seen from his report Bayou Black, above Tigerville, is now practically closed to navigation, except at high-water, and then only flat-boats can be cordelled through the cut-grass and weeds that now choke the channel.

The plan of improvement as submitted by Mr. Douglas is approved, and as the estimated cost of such improvement is based on that for similar work now in progress on the Terrebonne, his estimates are also approved.

Dredging in bayous like this and the Terrebonne is rendered difficult and expensive by reason of the number of logs found imbedded in the mud. These have to be raised by the dipper, and breakdowns are of frequent occurrence.

By act of Congress approved March 3, 1881, an appropriation of $10,000 was made for this work.

As the report of examination by Assistant Engineer Douglas was made so near the close of the fiscal year the forwarding of project for applica-

tion of the appropriation has been delayed. This will be attended to, however, as soon as practicable.

For continuing the work an additional appropriation of $37,520 is recommended for the fiscal year ending June 30, 1883.

The commercial importance of the work is indicated in Mr. Douglas's report.

A tracing of chart of examination will be forwarded as soon as made.

The work is located in the collection district of New Orleans. The nearest lighthouse is at the entrance to Atchafalaya Bay.

Total amount appropriated $10,000

Money statement.

Amount appropriated by act approved March 3, 1881	$10,000 00
July 1, 1881, amount available	10,000 00
Amount (estimated) required for completion of existing project	37,520 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	37,520 00

EXAMINATION OF BAYOU BLACK, LOUISIANA.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, *June* 28, 1881.

SIR: I have the honor to submit the following report on the examination of Bayou Black, Louisiana:

In obedience to your orders to take charge of the examinations of Bayous Black, Grand and Little Caillons, I left New Orleans, May 9, 1881, and proceeded to Morgan City, La., where I had three skiffs built for transportation of outfit, and field work of party.

On the 16th, party and outfit having arrived, the examination of Bayou Black was commenced and continued until completion May 23. Party comprised self and four men. Total length of bayous examined, 43 miles and 3,400 feet, extending from Morgan City to 4 miles above the town of Houma, and divided as follows: Bayou Bœuf, 8 miles and 2,000 feet, Bayou Chene 2 miles, and Bayou Black 33 miles and 1,400 feet.

In obedience to instructions the initial point of the examination was taken at Morgan City, the junction of Bayou Bœuf and Berwick's Bay, and extended up the Bœuf to Chene, down Bayou Chene, to the mouth of Bayou Black, and thence up the Black to Bayou Cane, above which point persons interested in the improvement of Bayou Black did not consider it necessary to extend the examination.

The weather was exceptionally fair, and the work, by the aid of a very efficient party, was pushed rapidly forward to conclusion without delay or incident worthy of mention.

The methods of work were the same as on preceding examinations. Transit and stadia were the instruments used for obtaining distances and bearings. Soundings were taken while going from station to station, as long as the bayou permitted the passage of a skiff; and after it had become choked with cut-grass, cross-sections were sounded at all bridges, and at points between when practicable.

The examination line lying mostly in open country there were but few opportunities of blazing trees or leaving other permanent station marks. No station or other marks of the preceding examination could be discovered on which to connect.

On the accompanying chart and in the following description the miles are counted from Morgan City up the Bœuf to Bayou Chene, down the Chene to the Black, and up the Black to the end of the examination line, following the direction in which the examination was made.

That portion of the Bœuf and Chene, covered by the examination extending from Berwick's Bay to the mouth of Bayou Black, is practically one bayou, having a least width of 300 feet, and least depth of 10 feet. They form a fragment of the net-work of bayous and lakes through which, at high river, the waters of the Atchafalaya find their way to the Gulf. Ordinarily the direction of the current in them depends upon the tide and wind.

The banks are the usual alluvial soil of the Louisiana lowlands, and vary from 2 to 8 feet above low-water. They are generally cultivated, sugar-cane being the principal crop, and where not cultivated they are heavily timbered with live oak, cypress, &c.

No serious obstructions were discovered in either of these bayous, the depth and width being ample for all vessels likely to navigate them. The distance by both bayous from Morgan City to the mouth of Bayou Black is 10 miles and 2,000 feet.

Bayou Black, for 5 miles after leaving the Chene, has a width of 120 feet, and least depth of 10 feet. The banks are from 2 to 4 feet high, and are uncultivated, having a heavy growth of timber and dense cane-brake upon them.

The trees overhang the bayou for nearly this entire distance, and are so thick that they could not be located separately.

However, as the depth of water is ample it is not at all likely that any vessel which will navigate the upper bayou, even after it is improved, would find any serious difficulty in getting through.

From the fifth mile to 8 miles 2,400 feet, which brings us to Tigerville, the bayou has a clear width of 100 feet and least depth of 8 feet. The banks average about 6 feet in height, sloping back, as is usually the case, to the cypress swamp, and are under cultivation, principally in cane.

Tigerville is a small town situated at the junction of Bayous Black and Tiger, and may be said to be the present head of navigation on Bayou Black, as above that point only flat-boats are run, and they only at high-water.

Bayou Tiger is the largest tributary of the Black, and is the drain of a large area of swamp land lying north of the Black. It is probable that the flow of water from this bayou has kept the Black open to this point up to the present time, as immediately above the junction it is practically closed.

The influence of the tide is felt up to this point, and would undoubtedly extend further but for the obstructed condition of the bayou.

From the mouth of Bayou Tiger to the end of the ninth mile, Bayou Black is practically closed to navigation. The width between banks is about 100 feet, with a depth of from 4 to 5 feet; but with the exception of a narrow channel scarcely wide enough for the passage of a skiff, the bed of the bayou is grown up with cut-grass and weeds, and these are encroaching rapidly on what open water remains. The character of the bottom is an exceedingly soft mud—so soft that it is difficult to detect where the water ceases and the mud begins.

There is a road on both banks, and the south bank has been cleared of trees to permit flat-boats to be towed or cordelled up and down the bayou. In this way during the rainy season when the bayou is high flat-boats are dragged over the cut-grass and weeds.

There are some small bushes on the south bank, and on the north a heavier growth of trees and brush. The open channel between the cut-grass has a present width of from 10 to 30 feet.

Tenth mile is generally similar to the preceding, except that the open water-way between the cut-grass and weeds is from 20 to 40 feet in width and has a least depth of 3.5 feet. The first quarter mile is heavy woodland on both banks; the balance is open and cultivated. Trees and bushes are growing on the north bank, while the south has but small brush.

Eleventh mile has about the same width of open water as the tenth, with a least depth of 3 feet, the bottom being the usual very soft mud.

There is a heavy growth of overhanging timber on the north bank for 2,000 feet, with the usual growth of willows and brush for the balance of the distance. South bank is open and cultivated, with small brush on the immediate edge of the bayou.

Twelfth mile, open channel varies from 20 to 40 feet, with a depth of 3.5 feet. North bank heavily timbered, and the usual brush, with a clump of willows near end of mile. South bank same as eleventh mile.

Thirteenth mile, open channel from 15 to 30 feet wide, and 3.5 feet deep. Brush and willows on both banks, the thickest and heaviest being on the north. Cultivated lands on both sides of bayou.

Fourteenth mile, open channel from 10 to 20 feet in width, by a depth of 2.5 feet. Almost impassable for a skiff. North bank lined with willows and small trees; south bank clear. The end of the fourteenth mile is at the bridge of the Live Oak plantation, and at this point I was compelled to leave my skiffs, as the bayou had become so badly obstructed by weeds, and the open channel was so narrow that it was impossible to get them further.

Fifteenth mile. The open channel has an average width of 10 feet, but at some places the cut-grass grows clear across the bayou. The depth of water is 2 feet, with a very soft bottom, into which a pole could be easily pushed 5 feet. Heavy brush on north bank and light brush on south bank. Lands on both sides cultivated. Near the end of this mile the ruins of an old timber lock are visible, in the shape of several charred piles. This, and another lock situated higher up the bayou, were built by a company, in years past, to maintain navigation in the bayou at low-water.

Sixteenth and seventeenth miles have a channel of the same width and depth as the fifteenth. Both banks have brush and small trees growing on them. Lands on south side cultivated.

Eighteenth mile. The width of the open channel increases slightly, being from 10 to 30 feet, the depth remaining 2 feet. About 1,800 feet of the north bank is woodland, but, with this exception, both sides of the bayou are cultivated lands. North bank is grown up with brush, and also the south bank for the first half mile, after which it is entirely clear.

Nineteenth to twenty-fourth mile, inclusive. To these the same general description will apply. The open water-way varies from 10 to 50 feet, this latter width being in pools. The depth is 1.5 feet, with the usual soft bottom. Channel closed in places by the weeds and cut-grass growing clear across. The clear and brushy banks are delineated on the accompanying chart. Both sides of the bayou are cultivated in small farms and large plantations.

Twenty-fifth mile. Channel from 10 to 15 feet wide, by a depth of 1.5 feet. Both banks clear and cultivated. The second old lock, previously referred to, is situated near the end of this mile, opposite Goode's sugar-house.

Twenty-sixth, twenty-seventh, and twenty-eighth miles have a channel of from 10 to 20 feet in width, with a depth of 1 foot, and a soft mud bottom. Brush on both banks thicker than below. Lands on both sides cultivated.

Twenty-ninth mile. At the end of the first 1,800 feet the open channel ceases altogether, the bed of the bayou being entirely grown up with cut-grass. At about this point Bayou de Large used to leave the Black, but only a trace of its head now remains. Both banks are grown up with trees and brush.

Thirtieth mile. Bayou bends nearly 180°, and, as in the preceding mile, there is no open channel, cut-grass and small trees growing in the bed of the bayou. This bend is so obstructed that it forms a dam retaining the waters of the upper bayou.

Thirty-first mile, to the end of examination line, 33 miles 1,400 feet. In this distance the width of the original bed of the bayou is nearly double what it was below. The bed is generally grown up with cut-grass, but there are occasional open pools in which, as the water is held by the obstructed condition of the thirtieth mile, there is a depth of 5 feet. The examination line terminated at a dam which has been built across the Black, immediately above the mouth of Bayou Cane. This latter bayou drains a large cypress swamp or lake, lying between Bayous Black and Terrebonne, which lake acts as a reservoir for the supply of both bayous.

Near the commencement of the thirty-first mile is the old Barataria Canal going across to Bayou Terrebonne, which bayou it strikes at the town of Houma, about half a mile from where it leaves the Black. This canal is grown up with willows and cut-grass. The bridges, of which there are quite a number across the bayou—nearly every plantation having one—are generally temporary affairs that could be easily removed. Nearly all of them are so arranged that an opening can be made in them to admit the passage of flat-boats.

From information received, and from observations, I know that quite a number of logs are imbedded in the soft mud of the bayou. In early days, when the banks were first cleared, the trees, principally live-oaks, were chopped down and allowed to fall into the bayou, where they have lain ever since. The cut-grass, with which the bayou is filled, grows very rapidly, attaining a height of from 6 to 8 feet, and in connection with a long vine-like weed, is rapidly closing the bayou. These weeds and grass occasionally form floating islands, some of which will sustain a man's weight.

The nature of the soil on Bayou Black and the general topography of the country indicate that it was at one time an outlet of the Mississippi River, and consequently a sediment-bearing stream. Its connection with the Mississippi was as follows: The waters of that river came down Bayou Lafourche, and from it into Bayou Terrebonne, thence into the Black or Little Terrebonne, as it was called at one time.

Bayou Black is no longer connected with the Terrebonne, nor the Terrebonne with the Lafourche, but the beds of the old bayous can still be traced. Bayou Black formerly left the Terrebonne at a point near Terrebonne Station, on Morgan's Louisiana and Texas Railroad, and it also had an outlet bayou known as Bayou de Large.

A reasonable explanation of the decadence of Bayou Black is that when its supply of water from the Terrebonne ceased it became a tidal bayou, with little or no current. The drainage of the lands which it traversed, then its only source of water supply, was away from the bayou to the swamp, as is common with most Louisiana bayous.

What rain did fall on the immediate banks only tended to fill the bayou up by washing in these banks, making it too shoal for navigation; when navigation ceased the weeds and cut-grass commenced to grow in the almost stagnant water, gradually encroaching on the channel until they closed it entirely.

I was informed that fifty years ago steamboats came up the Black to a point opposite the town of Houma, where now not even a pirogue could go.

COMMERCE.

For the following information in reference to the commercial importance of Bayou Black, I am indebted to Mr. Edmund McCollam:

In 1880 the products were about 5,000 hogsheads of sugar, 7,000 barrels molasses, and a large miscellaneous crop of rice, corn, potatoes, moss, &c.

Owing to the overflows of 1865, 1867, and 1874, very little sugar, which is the staple product, was cultivated on the lower portion of the bayou, but exemption from water for the past 7 years has restored confidence, and there is no reason why, in a very short time, the crop would not be more than doubled, as only about one-third of the land is at present cultivated in cane.

This is not, however, the only commerce that would be benefited by the improvement of this bayou. It is of great importance as a natural link in the chain of interior water communication between New Orleans and Southwestern Louisiana.

Private enterprise has already done a great deal in this section in the way of connecting various bayous, lakes, and bays by canals, and will undoubtedly continue this work.

To make Bayou Black available as a portion of a through route, these canals will have to be utilized and tolls paid by vessels using them to the parties owning said canals. As, for instance, should Bayou Black be improved by the general government, a vessel after coming up it on her way to New Orleans would have to pay toll through a private canal into Bayou Terrebonne, another toll to pass from the Terrebonne into the Lafourche, and still another to go from the Lafourche into Barataria Bay (see report on survey and examination of Barataria Bay), &c.

IMPROVEMENT.

Bayous Black and Terrebonne are alike in general character and topographical features, and the means used for improving one would be equally beneficial on the other.

In accordance with this the plan submitted for the improvement of Bayou Black is similar to the one now in operation on Bayou Terrebonne, viz:

To dredge a tide-water channel 50 feet wide and 6 feet deep from the town of Tigerville to the end of the examination line, near the town of Houma, a distance of 24 miles, and 4,000 feet.

The following estimates of the cost of the proposed improvement are based upon results already obtained in Bayou Terrebonne, and includes the removal of all obstructing logs, trees, and brush:

ESTIMATE FOR OBTAINING A NAVIGABLE CHANNEL 50 FEET WIDE AND 6 FEET DEEP IN BAYOU BLACK.

Removing snags and overhanging trees on the first, second, third, fourth, and fifth miles, at $300 per mile	$1,500 00
Dredging channel 50 feet wide, 6 feet deep, from Tigerville to the mouth of Bayou Cane, 24 miles 4,000 feet, at $1,600 per mile	39,700 00
Clearing off overhanging and standing trees at various points along proposed dredged channel, principally on the ninth, tenth, eleventh, twenty-ninth, thirtieth, thirty-second, and thirty-third miles	2,000 00
	43,200 00
Add 10 per cent. for contingencies	4,320 00
Total	47,520 00

As no level line was run, no exact knowledge of the depth of cut that would be necessary to carry tide-water up to Bayou Cane was obtained, but it is thought that the present bottom of the bayou is about tide-level.

The materials to be dredged is similar to that at present being excavated in Bayou Terrebonne, and it is thought that an equal number of logs will be found in the bottom of the bayou. It is difficult, if not impossible, to estimate such work by the cubic yard.

Your assistant and party were treated in a most kind and hospitable manner by the residents along the bayou, and material assistance in making the examination was received from Mr. H. C. Minor.

A chart on a scale of $\frac{1}{5000}$ accompanies this report.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

M 12.

IMPROVEMENT OF BAYOU COURTABLEAU FROM PORT BARRE TO ATCHAFALAYA, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in Report of Chief of Engineers for 1880, Appendix M.

By act of Congress approved June 14, 1880, an appropriation of $7,500 was made for its commencement.

In my report on this work for 1880 (see Report of Chief of Engineers that year, Appendix M 9), I stated as follows:

The principal obstruction in this portion of the Courtableau is Little Devil Bar, near its junction with the Atchafalaya. The bar varies in length at different seasons of the year, and at times is perfectly dry. To remove this bar by dredging would only benefit navigation for one low-water season, as the succeeding high-water would cause it to re-form.

To remove this bar and prevent its re-forming, it is proposed to close the run-out bayous to the south, of which there are 33 between Port Barre and the Atchafalaya. Before this can be done, however, to advantage, a detailed survey of the locality is deemed necessary to determine the best positions for the dams and the proper height to be given them, a necessity stated in the report of examination. A plan and estimate for such a survey, and the reasons for making it, were forwarded for approval July 8, 1880.

To further insure low-water navigation to Washington, with Little Devil Bar removed, there will be required a lock and needle-dam about 4 miles below Port Barre, and the commercial importance of the stream is deemed sufficient to warrant the additional expense for its construction.

In case it is only proposed to improve that portion of the bayou between Port Barre and the Atchafalaya, the following will be the estimate of cost:

Port Barre to Atchafalaya, clearing the bayou of snags, 18 miles	$ 900 00
Closing run-out bayous	20,000 00
One needle-dam and lock	15,000 00
Contingencies, 10 per cent	3,590 00
Total	39,490 00
Amount appropriated	7,500 00

The plan and estimate for the detailed survey forwarded under date of July 8, 1880, were approved by the Chief of Engineers under date of July 16, 1880.

The report of Assistant Engineer H. C. Collins, who had charge of the field work of the survey, is hereto appended.

On April 30, 1881, a project based on information obtained by Assistant Engineer H. C. Collins was submitted to the Chief of Engineers, and by him approved under date of May 20, 1881.

The following is the project. * * * *

It is therefore proposed to use the appropriation available for this work, or so much thereof as may be found necessary, for closing with raft the following named run-out bayous, viz: Bayous Jurommon, Big Fordoche, Mamzelle, English and Little Fordoche.

It may be necessary to do something toward securing natural rafts in several other bayous, but that can only be determined from result of work on the five named.

Those unnamed do not discharge at a lower stage than 10 feet above low-water, which is the stage below which it is designed to limit discharge from the Courtableau, except discharge directly into the Alchafalaya over "Little Devil Bar."

The method of rafting proposed is a very simple one, but the extent to which it should be carried will require good practical judgment on the part of the superintendent on the spot.

Suitable locations have been found on the bayous where there are standing living cypress trees on the banks and in the beds of the bayous for anchorages, and the banks above quite heavily wooded, so that trees may be felled into the bayous and drift

gradually accumulated, thus imitating and aiding nature, without attempting to force violent and very sudden changes.

Some artificial anchorages in the shape of piling may be found advantageous at points throughout the rafts to be formed, to take the place of snags observed to be of importance in such formation in the Red River above Shreveport.

It must appear evident that this work cannot be specified for contract. It is therefore proposed to do it by hired labor and purchase in open market. * * *

After the work proposed above shall have been completed and its results found sufficiently favorable, it is proposed, with such balance of appropriation as may be left and with such sufficient addition as may be made hereafter, to locate and construct a lock and needle dam to carry the low-water navigation of the Courtableau to Port Barre, and incidentally to the mouth of the Cocodrie (where the Cocodrie and Bayou Bœuf join to form the Courtableau), forsteam vessels that at that stage can, from New Orleans or elsewhere on the Mississippi River, reach the mouth of the Courtableau and cross Little Devil Bar.

This portion of the original general project submitted in 1879, for matters of detail must wait its time, that is to say, must await the result of the more important portion of the work and the making of adequate appropriation for its commencement.

Work in accordance with the above project will be commenced as soon as circumstances will permit and the proper arrangements can be made.

The work is considered to be permanent in the ordinary acceptation of the term as applied to works of this kind; its commercial importance was indicated in the report of the first examination.

By act of Congress approved March 3, 1881, further provision was made for this work by an appropriation of $7,500.

The work is located in the collection district of New Orleans. The nearest lighthouse is at the entrance to Atchafalaya Bay.

Original estimate	$40,000 00
Total amount appropriated	15,000 00
Total amount expended	1,218 61

Money statement.

July 1, 1880, amount available	$7,500 00	
Amount appropriated by act approved March 3, 1881	7,500 00	
		$15,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		1,218 61
July 1, 1881, amount available		13,781 39
Amount (estimated) required for completion of existing project, about		25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		25,000 00

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

ATCHAFALAYA RIVER, *November* 15, 1881.

SIR: I have the honor to submit the following report of the survey of the Courtableau from Bany's Landing to the Atchafalaya.

We reached Bany's Landing and began the survey on the 8th of September.

The Teche was then dry except for a small stream of rain-water running into the Courtableau. I ran a line down the Teche to where its banks were above the high-water mark of 1874 and its bed several feet above the low-water in the Courtableau.

The small stream was then running towards the Courtableau, showing that I had not reached the divide where the water would run to the southward. A cross-section is given on the chart at the head of the Teche and at the south end of the line, showing that as a stream for purposes of navigation it is perfectly worthless so far up, and that it is not even important to close it, as no water escapes that way with less than

a 10-foot rise of the Courtableau. Bench-marks were made on suitable trees and are located on the chart; a level line was run and a gauge kept; water-edge was taken frequently, and for the whole length of the survey bench-marks were made as often as it was thought necessary—74 in all.

Observations for meridian were taken every clear night. All bayous were examined, and on the important ones a line was run down from half a mile to a mile, giving sufficient distance to show where would be the best place for closing each bayou running out on the south side.

At the beginning of the survey the height of water was about 4 feet above the low-water of 1879, which was the lowest known, while Little Devil Bar was in its usual place.

When we reached Bayou Jurommon during a two days' rain, which delayed work, there was a sudden rise of 2 feet from backwater from the Atchafalaya; before that the current down the Courtableau was very slight 0′.1 per second, and for the time of the rise there was an up-stream current for the two days only, then a slight down current again as far as Big Fordoche, which took all the water of the Courtableau from above, and considerably more than as much from the Atchafalaya below.

Bayou Jurommon is the first bayou which may need closing; sections are given of it showing the area of the cross-section of the necessary dam; the banks are of blue clay, and no great washing need be expected.

Cypress trees growing in beds of the bayous, and which may be made available in their closure, are located on the chart.

The two cane bayous next below were examined and both found to be already closed by raft and sand, so as not to be outlet bayous at the height to which it is advisable to retain the water of the Courtableau.

Next is Mamzelle Bayou, which is rafted and in slow process of natural closure, but it can easily be entirely closed to the necessary height; at high-water a large amount of water is taken off by it, but a rise of 3 feet greater than that of the time I examined it would be necessary to take any water southward through it.

Next is Big Fordoche, which is by far the largest of these bayous, and which took the discharge of the Upper Courtableau, and a portion of that from the Atchafalaya with a rise of 6 feet above low-water; but had the Atchafalaya been low at the time, of course there would have been no water from it; the rise was owing entirely to the rise of the Atchafalaya. The line was run more than a mile down the Fordoche. The banks are of blue clay for a great part of the distance, and there are some drift piles on it. The cost of its closure would be less at the point of the lower cross-section, but perhaps it would be thought best to dam it nearer its head. The dam can be safely made at either place, or almost any point between.

The next is English Bayou; it is rafted with old raft, which is an obstruction at low-water, but a large amount of water passes with a 5-foot rise; there are three branches leaving it within a mile, and its closure will be best above the upper one, as the banks are there high and several cypress trees are available in channel to help in making the dam.

Next is Little Fordoche Bayou, the last of the large ones and the one which takes most of the water coming from the Atchafalaya direct. Its current was very strong, and Mr. Dupré, who lives near, told me that the two Fordoches, English, and Mamzelle bayous joined within 10 miles, runing to Butte la Rose. There are no inhabitants on either of them, and the whole country is under water nearly every year.

The closure of Little Fordoche near its head would be safest, as its banks are of blue clay above water, and are high, while farther down they are more sandy, though there are now blocks of old raft about a mile from its head, which so obstruct the current that there was a foot fall in 300 feet in one block of raft and a very strong current through among the logs.

I examined all the other bayous running out on the south side as far down as the Atchafalaya and they will be seen on the chart, but they are all closed by raft and sand, so that the water does not run out to the southward through them with less than a rise of 12 feet above low-water in the Atchafalaya. In making the examination of the Courtableau last year there was no time to examine these bayous and they were only indicated at their heads on that chart, and their real character entirely escaped notice. They are all filled by raft and reach down no lower than the blue clay of the old swamp, and, as shown by the large trees growing in the bottoms of their bed, and by other similar ones growing on their banks and on the land between the bayous are but original swamp and the banks between are filled in from the overflow of the Courtableau. So far up as this, water comes from the Atchafalaya, bringing with it a load of sand, most of which is deposited on reaching the banks and in the Courtableau, making what is called Little Devil bar—the same bar really extending southward through the woods as well as across the Courtableau.

Water which left the Atchafalaya River farther up at Petite Prairie Bayou and over its banks at higher stages of a general overflow is all the Atchafalaya water going above Little Devil Bar, and the load of that coming across the country has

been deposited before it reaches the Courtableau, so the channel above Little Fordoche is left entirely clear of this sand-bar. One hundred and forty-four cross-sections with a distortion of ten times are given on the chart, which is made on a scale of $\frac{1}{5000}$. The horizontal scale of cross-sections is $\frac{1}{10000}$, and the vertical scale $\frac{1}{1000}$. An examination of these cross-sections will show how continuous is the deep regular channel of the stream and just what is the form of the bar, all of which is of sand. It is believed that closure of a sufficient number of these bayous to turn a strong current from the Courtableau down its own channel instead of allowing it to empty itself down the five larger bayous will entirely sweep out this bar at the next high-water; but while the fall in the Courtableau is 6 feet below the level at which water stood above Little Devil Bar, low-water below that bar is 8 feet below the same level, Little Devil Bar being practically a dam forming a pool above it and allowing small boats to run above it up to Ouaxia Landing at lowest water, while with its removal no boats could at low-water go above Bany's Landing. A lock about the twenty-first to the twenty-fourth cross-section on the chart would be necessary to carry low-water navigation up to Washington, as was last year reported.

The levels now taken show that with this lock there would be fully all the water needed.

The very slight current of the bayou gave an excellent check on the levels, which were very carefully run by Mr. Hoffman, and much of the distance the line was run twice, checking between bench marks. Soundings were taken down the middle of the bayou for nearly the whole distance, as well as the cross-section sounding, but they were not of course located, while the soundings of the sections are each of them located; in this way a line is stretched across the river and each end at water edge located, a sounding taken at every 10-foot tag on the line, and the line is laid down on the chart where it actually ran, not always exactly at right angles to the direction of the channel as it might have been; trees standing were used to fasten the line instead of driving stakes in every case where it was convenient to use them.

The level of the flood of 1874 and of the high water of 1880 were found in many places, and they are given on the cross-sections. The heavy black line near the top of the section is 26,769 feet below the high-water mark at the head of Atchafalaya of the flood of 1874, and the line from which soundings are dropped is water level of the time the red line at the bottom is low-water, as it would probably be with Little Devil Bar removed.

The plan which I would make for closure of the bayous would be to select some place where cypress trees were growing in the channel (and such places are found in each of the bayous) or else to drive piles by which to fasten down a fascine dam; possibly some piles might be needed where trees formed a portion of the anchorage for the dams. Willow is growing in large quantities and is the most available material for the fascines, and instead of tieing the brush in bundles, it would probably make a cheaper dam if put in tightly as possible, using large and small brush as it came, and filling the bed of the stream for a length at bottom of about 100 feet, shortening the distance as the brush was piled on until the top was not more than 30 to 50 feet and sufficiently above the required top of the dam, so that when squared timbers were placed across it and forced down with jack-screws to the required level and bolted there to the trees, or to piles driven to hold them in place, the mass of brush underneath these cross-timbers should be sufficiently compact to let through but little water, and to cause the deposit of a sand-bar on its upper side and among the brush at the succeeding high-water. The willow brush would also root, and these roots help to retain the sand and mud, and soon would be formed a dam sufficiently tight to retain all the water nearly to its top, and by the timbers it would be prevented from using with the flood, allowing an uninterrupted flow of water whenever it should rise above its top.

Dredging out any portion of Little Devil Bar I would consider unnecessary, as, if a current is made down the Courtableau, it will be swept out of the channel and each year will build the south bank higher, so far up as the direct flow of the water of the Atchafalaya shall pass up the Courtableau at the great floods, and re-forming the bar in the channel to the same distance annually.

Any removal of Little Devil Bar which should require dredging must be a failure in practice, for it would require the same amount of dredging every year, and it would be reasonable to expect that the closure of the five bayous, or perhaps of four of them, would be permanent, and so long as they were closed there would certainly be no obstruction from the sand-bar.

Water of the Courtableau above the direct flow of the Atachafalaya is very free from mud and sand, having in great part come through cypress swamps where most of its suspended load of sediment was left.

November 10, when we reached the mouth of the Courtableau, on the Atchafalaya survey, the water was 1 foot below its height at completion of the Courtableau survey, but was fast rising in the Atchafalaya. It had risen from local rains in the Courtableau several days before, and there had been a very strong current out over the bar,

and the depth on the bar was, on the afternoon of November 10, 4½ feet, with the water 1 foot lower than its stage, when there was but 2½ feet depth, or a change by washing down of the sand on the bar of at least 3 feet in three or four days, but the rise of the Courtableau was then exhausted, and with the rise of the Atchafalaya the next morning of 1 foot there was no current, and afternoon a slight current up the Courtableau as far as Little Fordoche.

The difference of level above and below Little Devil Bar, November 10, was 1.144 feet, but the day before it had been a little more than 2 feet. The Courtableau water above the bar was nearly clear, but on and below the bar it was fully loaded with sand, and until it reached the Atchafalaya it was as muddy as the water of the Atchafalaya at the time.

The next morning it was clear, with no current.

The rise of the Atchafalaya was increasing the muddiness of that stream, and as the current changed and ran up over the bar the sand would be deposited on it. Had the five bayous been closed, their entire discharge would have been added to that which did deepen the sand bar 3 feet as it was, and the down-stream current would have continued keeping the muddy Atchafalaya water off the bar until it had risen to the top of the dams. In this case the rise of Atchafalaya stopped three days after.

Mr. Splan, the pilot of the steamer Fanchon, told me that there had twice been a sufficient rise of the Courtableau since the survey to have washed out the bar, had it been forced out over it.

The low-water of this year at the mouth of the Courtableau was 0.832 below the zero of Major Benyaurd's levels at the mouth of the Red River, at which the high-water of 1874 read 43 feet, and was 17 feet below the high-water of this year. In 1879 the low-water was lower, but I could not find how much. The low-water level above the bar is almost exactly the same as far up as Bany's Landing as it is at the bar.

Yours, respectfully,

H. C. Collins
Assistant Engineer.

Maj. C. W. Howell.

M 13.

IMPROVEMENT OF BAYOU TERREBONNE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with estimate and plan for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $10,000 was made for its commencement.

A project for expenditure of this amount was submitted to the Chief of Engineers and by him approved. (See Report of Chief of Engineers for 1880, Appendix M 7.)

Specifications drawn in accordance with the project were submitted, also, and approved; and after the work had been duly advertised under them, bids were received and opened, August 30, 1880.

The following is an abstract of the bids received:

Abstract of proposals received for improving Bayou Terrebonne, Louisiana (dredging).

[Bidder furnishing dredges and labor, and providing for inspector.]

No.	Bidders.	For excavation placed on bank of bayou.	Time of commencing work.
		Per cu. yd.	
1	D. S. Cage, vice-president and acting president South Louisiana Canal and Navigation Company.	$0 20	November 15, 1880

The bid of D. S. Cage (the only one received) was rejected as being too high.

Under date of October 29, 1880, the South Louisiana Canal and Navigation Company, through their agent, J. P. Viguerie, made the following propositions for doing the work on the bayou:

1 For dredging in Bayou Terrebonne, 14 cents per cubic yard.

2d. We will lease you our dredge-boat Sampson (Osgood pattern) for the sum of $10 per diem.

3d. Or we will lease dredge Sampson together with crew and fuel placed on the bank of the bayou, for the sum of $40 per diem.

4th. We will cut the overhanging willows on the banks of the bayou for the sum of $50 per mile.

In all bids we stipulate that payment shall be made monthly.

The second proposition, appearing the most advantageous to the United States, was recommended to the Chief of Engineers for adoption, and it having been approved by him, an agreement was entered into with J. P. Viguerie, agent South Louisiana Canal and Navigation Company, whereby he agreed to charter the dredge-boat Sampson to Maj. C. W. Howell, Corps of Engineers, acting in behalf of the United States of America, for the sum of $10 per day, Sundays excepted. The dredge was turned over to the United States, December 23, 1880, and dredging was commenced on the following day, at a point 23½ miles below Houma.

At the end of the fiscal year the boat had reached a point 16 miles from Houma, having dredged out 7½ miles of the bayou.

When the examination of this bayou was made, the water was comparatively high and the low-water surface undetermined; on this account the original estimate was too small. At present above the dredge-boat the bayou is from 10 to 15 feet wide and from 2 to 5 feet deep, being little more than a mere ditch.

There are two bad places that will require considerable work for their improvement, namely, the bend at Bisland's and the much more difficult one at the head of the Little Caillou.

The cost of the work already done has been $1,205.62 per mile; that which remains to be done will cost fully $1,500 per mile.

On this account an additional appropriation of $15,000 for the fiscal year ending June 30, 1883, is asked for, as necessary to carry the work to Houma.

16 miles dredging at $1,500	$24,000 00
Balance from previous appropriation	9,757 86
Amount required to complete the work	14,242 14
Or, in round numbers	15,000 00

This amount is considered none too small, as low-water navigation must be dependent on tide-water, and the dredging will have to be done with this object in view.

At present the bayou is only 11 feet wide where the boat is at work, and the bottom is much obstructed by sunken logs, stumps, &c.; it is even more contracted further up stream.

Unless the plantation ditches emptying into the bayou are changed so as to drain towards the swamps, this bayou will, for purposes of navigation, deteriorate year by year, and eventually and at no very distant period become choked with shoals, sure to form just below the mouth of each such ditch.

If the object in clearing out the bayou is to facilitate drainage, then there is no need of such extensive dredging as is required to insure easy navigation. With increased water-way the current will necessarily be-

come more sluggish, and, as a natural consequence, the tendency to shoal from sediment brought in from the adjacent fields during heavy rains will be greater even than in the unimproved bayou.

It is proposed to continue the work under the appropriation of March 3, 1881, as has been done heretofore, namely, by hire of labor and purchase in open market.

The commercial importance of the bayou was indicated in the report of the examination.

The work is located in the collection district of New Orleans. The nearest lighthouse is near the eastern end of Timbalier Island.

Total amount appropriated	$18,800 00
Total amount expended	9,042 14

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	8,800 00	
		$18,800 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	6,735 03	
July 1, 1881, outstanding liabilities	2,307 11	
		9,042 14
July 1, 1881, amount available		9,757 86
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		15,000 00

M 14.

IMPROVEMENT OF BAYOU LAFOURCHE, LOUISIANA.

This work originated from surveys authorized by act of Congress approved March 3, 1873, for report of which see Reports of Chief of Engineers for 1874, Appendix R 13, and 1875, Appendix S 5.

Under act of Congress approved June 18, 1878, appropriating $10,000, a portion of the work was commenced. (See Report of Chief of Engineers for 1879, Appendix K 3.)

By act of Congress approved March 3, 1879, a further appropriation of $10,000 was made available, and with a portion of this and a balance of the preceding appropriation, work was continued during fiscal year ending June 30, 1880.

By act of Congress approved June 14, 1880, an additional appropriation of $5,000 was made for continuing the work.

The close of the fiscal year of 1879 and 1880 found the work suspended on account of high-water in the bayou. Work was resumed on the 25th of August, 1880, the water in the bayou then having fallen to what was considered a suitable stage for recommencement of work of removal of such obstructions, as snags, stumps, raft-heaps, and wrecks. On this kind of improvement work was continued until December 13, 1880, when it was suspended because of too high-water to work to advantage. The work done during the season is summarized as follows:

Logs, stumps, and snags removed	694
Stumps cut on banks	77
Number of working days (actual)	104
Days lost unavoidably	10

The field of work extended from a point 3 miles below Lockport to a point 8 miles below the same place.

On September 11, 1880, the overseer, Asa H. Holgate, died, and Peter Oliver was assigned to duty in his place.

The work, so far as that portion contemplating removal of obstructions is concerned, may be considered as susceptible of permanent completion.

The work is located in the collection district of New Orleans. The nearest lighthouses are at the mouth of the Mississippi River and at the entrance to Atchafalaya Bay.

Original estimated cost	$100,000 00
Total amount appropriated	25,000 00
Total amount expended	16,222 33

As the unexpended balance of the amounts already appropriated are deemed sufficient to complete the work of improvement under the present project, no additional appropriation for the fiscal year ending June 30, 1883, is recommended.

Work will be resumed as soon as the water in the bayou has reached a proper stage for commencement of operations, and will be conducted, as heretofore, by hire of labor and purchase in open market.

Money statement.

July 1, 1880, amount available		$13,005 17
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	$4,160 90	
July 1, 1881, outstanding liabilities	67 50	
		4,228 40
July 1, 1881, amount available		8,776 77

M 15.

IMPROVEMENT OF CALCASIEU RIVER FROM PHILLIPS' BLUFF TO ITS MOUTH, LOUISIANA.

This work originated in an examination authorized by act of Congress approved June 14, 1880, a report of which, together with plan and estimate, was published in House Ex. Doc. No. 54, Forty-sixth Congress, third session.

By act of Congress approved March 3, 1881, an appropriation of $3,000 was made for commencement of the work.

Under date of April 30, 1881, the following project was submitted to the Chief of Engineers for his approval:

PROJECT.

It is proposed to let the work out at contract to the lowest responsible bidder, who bids for the greatest number of miles from Phillips' Bluff down stream (as per chart of survey in this office), $300 to be reserved for inspection, &c.

As an inducement to local bidders as well as others, it is proposed to offer use of the United States survey boat, now laid up at Lake Charles City, and which is costing the United States $5 per month for care.

The boat is suited for the work and can be outfitted properly at expense of perhaps $300.

This project was approved under date of May 12, 1881, and specifications having been drawn in accordance with it, and having been submitted to the Chief of Engineers and by him approved, advertisements inviting proposals were published in the proper papers June 30, 1881.

Bids will be opened July 30, 1881.

The work is not considered permanent, as the obstructions caused by snags, sunken logs, and fallen trees are liable to reform at any time.

The commercial importance of the river was indicated in the report of examination.

The work is situated in the collection district of Galveston, Tex. The nearest lighthouse is at the entrance to Calcasieu Pass.

Original estimate	$10,080 00
Total amount appropriated	3,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$3,000 00
July 1, 1881, amount available	3,000 00
Amount (estimated) required for completion of existing project	7,080 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	7,080 00

EXAMINATION OF CALCASIEU RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, January 10, 1881.

GENERAL: I have the honor to submit herewith the report of Assistant Engineer A. C. Bell upon a recent examination of the Calcasieu River, in Louisiana, which examination was provided for by act of Congress approved June 14, 1880, and under date of June 17, 1880, assigned by the Chief of Engineers, U. S. A., to this office for execution.

* * * * * * *

It will be noted, from Assistant Bell's report, that at the time of examination the "head of navigation" was found 28 miles below Phillips' Bluff, and that the examination was only carried to the upper end of Lake Charles and to cover a small portion of the lake beyond its entrance. This is in strict accordance with the wording given in the river and harbor act providing for the examination.

Mr. Bell states that he did not find a less depth at the mouth than is said to be available through the lake, viz, 8 feet.

Since the examination was completed, I have learned that it was probably intended to have the work extended through Lake Charles and Calcasieu Pass to the Gulf of Mexico; but if it had been so stated in the river and harbor act, I should probably have submitted as my project a statement that I considered such extension unnecessary, in view of information on hand dating back to 1871 and 1874, which it is thought is sufficient guide, when taken in connection with statements of the filling of dredged channel of 1874 at head of Calcasieu Pass, for estimates to-day, without making re-examination, on which to base the latter.

So, in submitting recommendation, in addition to report of recent examination, I beg leave to refer to my reports of 1871, 1873, and 1874, to be found in the annual reports of the Chief of Engineers for those years, and will assume the dredged channel of 1874, at head of Calcasieu Pass, as completely obliterated, so as to restore normal condition at the head of the pass, also condition of Gulf Bar, as reported in 1871.

It is first recommended that the river be improved, from Phillips' Bluff to its debouche at the head of Lake Charles, by the removal of obstructions noted in the report of Mr. Bell.

The estimate for such removal, as submitted by Mr. Bell, is made in accordance with estimates for similar works, and is considered sufficient. In the second place, I beg leave to renew my recommendation of 1871, also my estimate for a channel between the lake and the pass, as given in that report; also my statement of importance of the work, and in addition will say that I consider this latter the most important part of the work recommended. In the third place, I would suggest that if appropriation be made for the work recommended, it be made under two headings, viz:

1. For dredging at head of Calcasieu Pass $15,000
2. For improvement of Calcasieu River, Louisiana, from Phillips' Bluff to its mouth 10,080

I think this division very desirable in view of the possibility that the whole estimate may not be appropriated, and, in consequence, the decision of relative importance thrown entirely upon the Executive.

Total estimate, $25,080.

The commercial importance of the work is indicated in Mr. Bell's report, and in previous reports herein referred to.

The nearest light-house is at the entrance to Calcasieu Pass.
The work is located in the collection district of Galveston, Tex.

Chart of examination will be forwarded as soon as tracing can be made for retention in this office.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

NOTE.—In reply to telegraphic inquiry, addressed to a well-informed business man of Lake Charles City, a gentleman largely interested in the lumber trade of that region, and known to be well informed, I have received the following telegram since closing report, viz:

Present depth of water in Calcasieu Channel, from 4 to 5 feet.
Depth desired for vessels, from 7 to 8 feet.

O. T. SCHINDLER.

This information supports my conclusion as to filling of channel at head of Calcasieu Pass, justifies estimation for reopening channel based on assumption of entire refilling; at the same time it shows that the channel has not *entirely* refilled, also that the demand for depth has increased.

That the channel has not entirely refilled after six years of neglect is considered favorable to a proposition for redredging it.

C. W. HOWELL.

REPORT OF MR. A. C. BELL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
New Orleans, January 4, 1881.

MAJOR: I have the honor to submit the following report of examination of Calcasieu River. * * * For convenience of description I divide the river in two sections with reference to the cost and difficulty of improving the same.

FIRST SECTION

comprises the distance from Phillips' Bluff to the end of the 28th mile, which is now the head of navigation.

The river meanders through a low gum swamp, about 1 mile in width, which is sub-

ject to overflow at high-water; said swamp is terminated on either side by high piney woods, not subject to overflow.

In the first 8 miles there are three cut-offs to be closed, which can be easily accomplished by floating into them the snags and leaning trees removed from the main river; 119 snags and 319 leaning trees to be removed. I would recommend using Wood's Lower Cut-off, which leaves the river at the 8th mile, as the channel; the main river being much obstructed by sunken saw-logs, and a sand-bar extending the entire width of the river. Fully one-half the volume of water in the river passes through this cut-off; the distance would be shortened but little by the new route.

In the next 12 miles, 197 snags and 470 leaning trees are to be removed. At the end of the twentieth mile the river contracts to a width of 95 feet; it retains this width for a distance of 1¼ miles. This portion of the river is known as the narrows; the banks are bluff, composed of sand and clay; the current attains an average velocity of 3 miles an hour at ordinary stage of water; 41 snags and 63 leaning trees to be removed; least depth of water, 7 feet.

At the end of the twenty seventh mile there is a very bad bar; at low-water there is scant 6 inches of water on it. The bar is 100 feet in width by 600 feet in length; there is a channel on the east 15 feet wide and 7 feet deep. This bar has been formed by the accumulation of snags below the head of Stackpole Cut-off; if the snags were removed and the cut-off closed, the accelerated current of the river would soon carry away the sand deposit.

The next 7 miles require the removal of 95 snags and 203 leaning trees. The difference between high and low water in this section of river is about 8 feet; average rate of current 2 miles per hour.

Boats have run up this section as high as Grey's Landing, 16 miles below Phillips Bluff.

The cost of removing these obstructions would be $200 per mile, making a total for the 28 miles of $5,600.

SECTION SECOND

includes from the twenty-eighth mile to the entrance of the river into Lake Charles, 28 miles below. This section of river meanders through a swamp similar to the upper, but is separated from it by banks about 12 feet wide and from 3 to 4 feet in height, thus forming natural levees. A number of large bays border the banks of the lower river, having an average depth of 20 feet. In the next 19 miles the river is widened and deepened, and the volume of water greatly increased by the junction of three large bayous; 97 snags and 101 leaning trees are to be removed. At the forty-eighth mile occurs the junction of the West Fork; here the river widens abruptly to 500 feet and a depth of 30 feet, which it retains to the mouth. In the remaining 9 miles 24 snags and 34 leaning trees are to be removed.

I found no bar at the mouth, the least depth being much greater than that of Lake Charles, which is 8 feet. The whole of this section is affected by tide-water, the rise and fall being about 2 feet.

The amount required is estimated at $100 per mile, making a total for the 28 miles of $2,800.

RECAPITULATION.

First section, 28 miles, at $200 per mile	$5,600
Second section, 28 miles, at $100 per mile	2,800
Add 20 per cent. for contingencies	1,680
Total	10,080

A chart plotted on a scale of 1 to 5,000 accompanies this report, on which all obstructions are noted, and the depth in feet given, at intervals along the entire length of the river.

The commerce to be benefited consists of 2,000 bales of cotton, which now takes the overland route to the railroad. I have no doubt that were the river made navigable a number of rice farms would be located, as large areas of marsh are to be found on the edge of the piny woods. Rafting and floating logs to market is the principal business carried on in the upper river; 18,000 saw-logs were floated down the river in the past year. Seven saw-mills are located near the mouth of the river; each will cut on an average 400,000 feet of lumber per month, making a total for the seven mills of 2,800,000 feet per month. The greater part of this lumber is shipped by schooner to Galveston, to supply the Texas market.

The following report of tonnage and crew entering the river has been kindly furnished by the deputy collector of Calcasieu Pass:

Months.	Crew.	Tons.
July, 1879	131	2,968.64
August, 1879	85	908.00
September, 1879	43	1,411.34
October, 1879	72	2,098.78
November, 1879	63	1,455.11
December, 1879	91	1,841.06
Total	485	10,682.93

Very respectfully,

A. C. BELL,
Assistant Engineer.

M 16.

IMPROVEMENT OF CALCASIEU PASS, LOUISIANA.

HISTORY.

An examination of this pass was made in 1871, and a project, together with plan of improvement and estimate of cost of same, published in Annual Report of Chief of Engineers for 1871. Appendix N 12.

By act of Congress approved June 10, 1872, an appropriation of $15-,000 was made for this work, and under date of June 24, 1872, a project was submitted to the Chief of Engineers for dredging a channel 80 feet wide and 5 feet deep at mean low-tide, across the bar, at the foot of Calcasieu Lake, the dredged material to be deposited on side of cut.

The work to be done by hired labor and purchase in open market, using the government dredge-boat then at work on Red Fish Bar, Galveston Bay.

The cut was completed January 14, 1874, and at that time was 60 feet wide, €½ feet deep, and 6,300 feet long.

Since that time the cut has filled up somewhat, just how much is not known.

By act of Congress approved March 3, 1881, an appropriation of $12,000 was made for re-opening the cut.

APPROPRIATION OF 1881.

Under date of April 30, 1881, a project for expenditure of this appropriation ($12,000) was submitted to the Chief of Engineers.

PROJECT.

It is proposed to re-open the United States Cut through the bar in Calcasieu Lake at the head of the pass (made in 1873 and 1874) by deepening and widening it. The depth proposed is 8 feet at mean low-tide, width 70 feet at bottom, and length 7,500 feet, the material dredged to be placed in embankment on either side of the cut as most convenient, the line of cut to be marked out by the United States, and plane of reference established to guide contractor.

No payment to be made until satisfactory completion of work.

The limit of bids to be placed at $10,800, the balance of $1,200 to be reserved for marking channel, for inspection of work, and for pro rata of office expenses, including advertisement, &c.

This project having been approved, specifications drawn in accordance with it were submitted to the Chief of Engineers, and having also

been approved, advertisements inviting proposals were published in the proper newspapers June 30, 1881.

Bids will be opened July 30, 1881.

The work is not considered permanent in the ordinary acceptation of the term, as the cut is liable to be gradually filled up; on this account the depth has been placed at 8 feet to prolong its usefulness.

The commercial importance of the work was indicated in my annual report for 1871, and in the report of Assistant Engineer A. C. Bell, published in House Ex. Doc. No. 46, Forty-sixth Congress, third session.

The work is located in the collection district of Galveston. The nearest light-house is at the Gulf entrance of the pass.

Original estimate	$15,000 00
Total amount appropriated	12,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$12,000 00
July 1, 1881, amount available	12,000 00
Amount (estimated) required for completion of existing project	3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	3,000 00

M 17.

EXAMINATION OF BAYOU ANDRE, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February 3, 1881.

GENERAL: I have the honor to forward herewith report of Assistant Engineer H. S. Douglas, relative to an examination of Bayou Andre, Louisiana, provided for in section 2 of the river and harbor act approved June 14, 1880.

When the examination was assigned to this office I found that the bayou was not noted on the State or other maps that I had for reference.

I had not before heard of it, and, after inquiry, I found that it was somewhere near the lower end of Barataria Bay, but could get little information about it; so I assigned its examination to the party of Assistant Douglas, which party was given the Barataria line of surveys and examination as distinguished from the Atchafalaya, a line farther west, given to the party under charge of Assistant Collins.

Mr. Douglas found the bayou and made an examination of it, as per his instructions, and his report shows that, so far as the bayou is concerned, there is no pressing call for its improvement.

The report also indicates that the shoal bays at either end of the bayou need dredging for considerable distances, to carry the available depths of the bayou from Barataria Bay to Bayou Lafourche, through the canal of the South Louisiana Canal and Navigation Company, connecting Caminada Bay with Bayou Lafourche, and thence through to Bayou Terrebonne and Bayou Black to the Atchafalaya, near Morgan City.

It now transpires, since the location of the bayou has been ascertained and examination concluded, that this connection was probably the main object of provision for examination, and that this office, although making inquiries in all directions suggested to it, has not by its examination

covered all the desired ground, but has simply covered Bayou André, as was provided for by the wording of the act of Congress.

I think that it is to be regretted that the wording of the act was not made sufficiently explicit, and that those who desired its passage with this item have since been so reticent about giving this office full information, because it would have cost but little more while examination was in progress to have run a few lines of soundings across "Caminada Bay" and "Bay des Islets," sufficient to make approximate estimate for dredging a channel through them, and because the route, of which this dredged channel would form an important link, although at present only a matter of private enterprise, may become a matter worthy of State or of national aid. After examination was completed it was not possible to do more in the way of examination, because there was no United States money available to do it with.

The work is located in the collection district of New Orleans, and the nearest lighthouse is on Grand Terre Island, at entrance to Barataria Bay, Louisiana.

It is recommended that provision be made for a survey of Bay des Islets and Caminada Bay, with a view to preparation of plans and estimates for dredging channels through those bays to connect Barataria Bay with Bayou André, and the latter with the canal to the Lafourche by a 5-foot channel.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
New Orleans, January 6, 1881.

SIR: In obedience to your orders, while engaged upon the survey of Barataria Bay, &c., I also made an examination of Bayou André. Two days in November, 1880, when the weather was unfavorable for work in the bay, were utilized for this purpose, and the following report is submitted in advance of the completion of the chart.

Bayou André is one of the numerous bayous which intersect the sea marsh lying between the Mississippi River and Bayou Lafourche, and is of importance inasmuch as it is the chief pass through the narrow strip of marsh separating Caminada Bay and Bay des Islets; and all trade to Cheniere, Caminada, or westward via the Lafourche Canal, has to pass through this bayou.

Bayou Andre is not named on the large maps of the State, but may be found on a chart dated 1842, entitled "A Military Reconnaissance and Survey of the Approaches to New Orleans from the Gulf of Mexico," made under the direction of Capt. G. W. Hughes, United States Topographical Engineers. Its form has changed greatly since that date, owing to the washing away of the narrow neck of marsh land through which it flows.

At present the bayou is 3,000 feet long by 1,000 feet wide, with a 5-foot channel through it. The general character of the bottom is a soft, sticky, black mud slightly mixed with shells. Its banks are the ordinary sea marsh, overflowed by high-tide.

The only obstructions discovered were two shell banks of small extent, with about 1 foot of water over them at low-tide.

On these, boats beating through the bayou sometimes ground, though a good channel can be found around them. Their removal would not seem absolutely necessary.

A better channel exists through the bayou than can be found in either of the bays that it connects. At its western end in Caminada Bay there is but 2.5 feet of water, and this flat extends over a large portion of that bay. I was informed that after crossing this flat 4 feet of water could be found along the northwestern shore of the bay. At the eastern end of Bayou André is Bay des Islets, another shoal bay, with but 3 feet water over almost its entire area. The improvement that seems to be required is to connect the deep water which extends up Pass Mendiant from Grand Pass

with the deep water (if it exists) in Bay Caminada. This would, however, necessitate a survey of Bay des Islets and Caminada Bay, in addition to Bayou André, which is also the only connecting pass.

I could obtain but little information as to the commercial importance of this bayou, but while I was in the vicinity from two to ten luggers passed through every day. These boats vary from 3 to 12 tons measurement, and were loaded principally with oysters and fish for the New Orleans market.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

M 18.

SURVEY OF BARATARIA BAY, FROM NEW ORLEANS TO GRAND PASS, AND OF LITTLE LAKE AND BAYOU ANDRÉ.

For the above-named survey and examination provision was made in the river and harbor act (second section) approved June 14, 1880.

The several places designated, forming parts of a connected system of inland navigation in Southern Louisiana, together with their connections, have been surveyed or examined as provided for, and as set forth in the report of Mr. H. S. Douglas, assistant engineer, which report is appended.

The plotting of the field notes has been completed on four large sheets now on file in this office.

In 1842 a survey and reconnaissance covering all of the field now recovered (and very much more) was completed, under direction of Capt. G. W. Hughes, topographical engineer, for military purposes.

The chart of this "survey and reconnaissance" bears on its face evidence of careful and minute work, and has not only been accepted for purposes of comparison, but, to avoid expense of reduction of plotting of recent work to the same scale, has been used for purposes of an "index chart," herewith, and to note changes.

It is requested that the index chart be published as a part of this report, because without it no description could give, to more than a very few, a definite idea of location of this one navigable system of "Mississippi River delta," bayous, lakes, and bays.

The chart of Captain Hughes, of which I have availed myself, is evidently a reduction from the detailed charts of survey, and so does not permit going into minute details of comparison, but is yet considered sufficient for all practical purposes of comparison, having in view the important matters of natural changes of depth and width and location of navigable channels.

Taking into consideration possible difference of 6 inches or 1 foot in planes of reference for soundings, comparison does not show material change in depths found during the interval (of 39 years) between surveys.

Changes in widths and in shore lines generally have been so slight that they cannot be noted on a small scale comparative chart, and are considered unimportant.

The exceptions are the narrowing between the headlands of the pass connecting Barataria Bay and the Gulf, and the widening of Bayou André.

The former is considered especially worthy of note.

In 1842, the width between headlands was (as nearly as can be meas-

ured on the reduced chart of that date) 6,340 feet, while at the date of recent survey it was but 1,600 feet, *yet the depth in throat of pass has not materially changed.*

The survey did not cover the outer bar of the pass, because for the time limited by means at command there was no favorable weather for such work. The Coast Survey chart of 1879 is therefore referred to for information in regard to depth over crest of bar and seaward slope.

Assistant Douglas, it is thought, sufficiently describes obstructions to be removed and cut-offs that may be made to secure a good navigable channel 5 feet in depth, from the Mississippi River opposite New Orleans to the Gulf of Mexico. He also presents estimates that are considered sufficient in amount, and besides gives as good a statement of commerce to be benefited as could be obtained by him.

Appended to his report is a statement of tolls charged on the three private canals now in operation and interested, as far as these tolls have been reliably ascertained.

The survey and examination has covered substantially the line proposed for the "Barataria Ship-Canal," designed to secure deep-water navigation between the Mississippi River and the Gulf of Mexico.

This latter enterprise has been chartered by the State of Louisiana, and has been granted right of way by the United States.

Out of the amount allotted to this office ($18,000) for surveys and examinations assigned to it, there has been expended on the above-reported works the total sum of $2,405.43.

The work is located in the collection district of New Orleans, and the nearest lighthouse is that at entrance to Barataria Bay.

REPORTS OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

1.

NEW ORLEANS, *April* 23, 1881.

SIR: In obedience to your order to take charge of the surveys and examinations of Barataria Bay from New Orleans to Grand Pass, Little Lake, and Bayou André, I chartered the sloop Zephine with a sailing master and sent her around, via the Mississippi River and Gulf of Mexico, to the head of Harvey's Canal, the proposed initial point of the survey, where she arrived September 18, 1880.

Provisions and outfit were put aboard and party organized by the 21st.

On the 22d field-work was commenced and continued until completion. By the kindness of Capt. J. H. Harvey, three skiffs were furnished the party free of charge. For this and many other kindnesses your assistant was indebted to this gentleman. Party consisted of self and 6 men.

Survey was commenced on the right bank of the Mississippi River opposite the city of New Orleans, at the head of Harvey's Canal, the survey of which was completed September 29; thence the line was continued down Bayou Barataria, completed October 7; thence through Bayou Rigolets to Little Lake, completing it October 13; thence over Little Lake, the survey and examination of which was completed October 21; thence down Bayou Saint Denis to Barataria Bay, arriving at latter October 24. Then sailed directly to Fort Livingston where headquarters were established and outfit disembarked to put sloop in good trim for work in the bay. The survey and examination of the lower portion of Barataria Bay, and also the examination of Bayou André were made while at this point. Completed this work November 30, two days being taken for Bayou André.

Re-embarked outfit and returned to the junction of Bayous Saint Denis and Cutler, for the purpose of examining the latter. Ran careful examination line to the head of Bayou Cutler, finishing same December 6. Returned to Barataria Bay and completed triangulation and hydrography of same December 10.

Returned to Bayou Dupont which leaves Bayou Barataria at the same point as Bayou Rigolets and made examination of same, completing field-work December 14. Returned to New Orleans and discharged party December 15, 1880. The field-work throughout was greatly retarded by bad weather, the winter of 1880 being unusually severe in this section.

Commencing at △0 head of Harvey's Canal, a careful azimuth line was carried to △115, at the head of Bayou Rigolets. A Gurley transit was the instrument used, and distances were measured by stadia, this latter being frequently checked by measurement with a Chesterman steel tape. A stake from 2 to 3 inches in diameter, having a nail driven in its top, marked the instrument points or stations. Trees, when within 10 feet of these points, were blazed and marked with the number of the station. Cross-sections were made by means of a marked line stretched from bank to bank, the ends of which being located, the soundings were taken from a skiff at equidistant intervals on this line. Frequent soundings were made between stations to discover any unusually shoal places at which it might be necessary to take cross-sections. Obstructions in the way of snags, &c., were located by stadia measurement.

At △115—commencement of Bayou Rigolets—the azimuth line was dropped, as the nature of the country traversed would not admit of an instrument being set up with the necessary degree of steadiness, and from this point a careful compass line was run. On account of the yielding nature of the soil, but few permanent station marks were left. Soundings were taken between located points on time, and there being no current in the bayou they were quite accurate.

On reaching Little Lake several plans for locating soundings were tried before one was adoptéd—this one being to place an observer on shore at a conspicuous station with a transit, and another on board the sloop with a sextant. The raising and dropping of a flag at the masthead enabled the two observers to read simultaneous angles, thus locating points at intervals on the various lines of soundings. The soundings were taken on time and spaced in between the locations thus obtained.

A tide-guage was established in Little Lake, and mean low-tide obtained from two months' observations. Having no level, no bench-marks could be established in reference to this gauge.

For the purpose of locating points and connecting the work a careful shore line was run on the eastern shore of the lake from the mouth of Bayou Rigolets to the head of Bayou Saint Denis.

On Bayou Saint Denis the survey was similar to that on Bayou Rigolets.

In Barataria Bay, owing to its size, the same methods followed in Little Lake could not be adhered to. A base line was measured on Grand Terre Island, from the light-house to an old sugar-house chimney. This base was measured with a 100-foot Chesterman steel tape and re-measured back to check any error. From this base a system of triangles was thrown over the bay, connecting with the line on Bayou Saint Denis.

Soundings were located in the lower portion of the bay in the same manner as they had been in Little Lake. In the upper portion of the bay, where the depth of water is quite even, locations were taken by reading angles with the sextant between three stations.

A tide-gauge was established in Customhouse Bayou, at Fort Livingston, and mean low-tide obtained by about two months' observations.

This gauge is referred to two bench-marks established by water level. Shore line was run wherever practicable, but with the limited time and money it was not possible to traverse the entire shores of Little Lake and Barataria Bay.

On Bayous Cutler, Dupont, and André the mode of operations was similar to that on Bayou Rigolets, except that occasional cross-sections were taken.

HARVEY'S CANAL

is one of the two routes by which Barataria Bay is connected with New Orleans. It is an artificial cut 5 miles and 2,000 feet long, by a least width of 47.5 feet and depth of 5.5 feet. It extends from the Mississippi River to Bayou Barataria. Heretofore boats have been hauled over from the canal into the Mississippi by a marine railway, but at present locks are in course of construction. These locks are to be 200 feet long by a width of 35 feet and it is expected to have in them a depth of 8 feet at low-water of the Mississippi.

Harvey's Canal for the first mile transverses cultivated lands, after which it passes through cypress swamp to Bayou Barataria. Its banks at first are high, gradually sinking to swamp level. The canal is supplied from tide-water, and it may be here stated that the entire survey lay in tide-water. By this and the company's canal all trade between New Orleans and the Barataria country has to pass.

BAYOU BARATARIA,

from where Harvey's Canal enters it to where it ends, and Bayous Rigolets and Dupont commence, has a length of 16 miles and 3,420 feet. From the first to the tenth mile the depth increases from 8 to 15 feet, and the width from 140 to 180 feet. On the eleventh mile it receives a portion of the waters of Lake Salvador, through Bayou Villars, which increases its width abruptly to 400 feet, the depth remaining about the same. From the entrance of Harvey's Canal to the fifth mile the bayou passes through

a dense and deep cypress swamp, interspersed with occasional strips of sea marsh and a few high knolls, on which are the shanties of the swampers. The swamp is pretty well cleared of the valuable cypress timber in places, it having been cut for the use of the saw-mills, of which there used to be several. Numerous small bayous enter the main one, and swell its volume.

From the fifth mile to the end the banks average from 2 to 4 feet high, and are fringed with live-oaks. The adjoining lands are generally under cultivation, and are thickly settled. Sugar-cane is the principal crop raised on several large plantations.

The obstructions to navigation in the shape of snags and overhanging trees are not numerous, there being 143 overhanging trees and 33 snags, all to be found in the first 11 miles of bayou. A floating draw-bridge at Berthoud's plantation, on the eleventh mile, is complained of; the width for the passage of vessels not being deemed sufficient.

Two abrupt bends are also considered obstructions by persons navigating the bayou. The first of these is on the fifth mile, and is known as the Free Camp Bend; the other on the sixth mile, and known as the Peach Orchard Bend. This is the only one of the various bayous embraced in this report traversing timbered lands. The others are almost entirely sea-marsh bayous.

BAYOU RIGOLETS

is one of the two bayous into which Bayou Barataria is divided. The other and smaller bayou is known as Dupont or Smuggler's Bayou. Bayou Rigolets is a sea-marsh bayou, widening out to almost a lake in places. Its length measured down the center is 10 miles and 3,000 feet.

In the first mile it widens out from 415 to 1,500 feet, and the depth decreases from 23 to 5 feet.

Between the first and seventh miles it attains an extreme width of 2,800 feet, the 5-foot channel being continuous.

From the seventh to the tenth mile the bayou again contracts to a width of 400 feet, and deepens to 12 feet. About the middle of the tenth mile Bayou Perot, another outlet of Lake Salvador, enters from the north; and from thence to Little Lake there is a width of 1,000 feet, and depth of 23 feet. The banks are low sea-marsh, averaging about a foot above low tide. A great deal of it is *prairie floatant*, and in places the motion of the waves could be noticed 50 feet back of the apparent bank. This bayou is what may be called a dying one, as every year the banks advance their line of reeds; and wherever a duck hunter constructs a blind, an island is commenced which rapidly grows.

At the junction of Bayou Perot is the Little Temple, a high shell-bank covered with a growth of live-oaks.

This is the first of several similar islands met on the line of the survey. They are called *chenières*, or oak-ridges, by the inhabitants of the country; and on these the people generally live, they being the only firm ground to be found.

Near the end of the eighth mile a canal has been cut across the sea-marsh into Lake Villars, which opens into Bayou Saint Denis. This canal is about $2\frac{1}{4}$ miles long, with a width of 40 and depth of 4 feet. It was cut to avoid the bar at the head of Little Lake known as Pointe le Garde Bar. Very little benefit is derived from it, however, as there is but 3 feet water in Lake Villars into which the cut opens.

LITTLE LAKE

is a sheet of water 7 miles long with an average width of 2 miles, covering an area of 14 square miles.

It has an average depth of 5 feet at low-tide and the general character of bottom is a sticky mud mixed with shells.

The shores of the lake are the usual sea marsh with a few *chenières* and shell-banks.

At Clark's Chenière there is a settlement of fishermen and hunters, and on the various bayous emptying into the lake are quite a number of small settlements.

The tides in the lake are greatly influenced by the winds, a strong norther sometimes driving the water out to a point considerably lower than the plane of reference used on the survey.

In past years it was a salt-water lake, but now it is only occasionally so. At the time of the survey it was fresh enough for drinking purposes. This change is supposed to be caused by Mississippi water coming in through the company's canal, but the quantity is so inconsiderable that it cannot have much effect. The shoal water on Pointe le Garde Bar, at the entrance of Bayou Rigolets and at the head of Bayou Saint Denis, are the only obstructions to the navigation of the lake. The first-mentioned, Pointe le Garde, is the worst obstruction at present existing on the route between New Orleans and Grand Pass. The distance between 5 feet water in the mouth of Bayou Rigolets and the same depth in Little Lake, across this bar or flat, by the most

direct route, is 8,500 feet, and over the greater part of this distance there is a depth ot but 2 feet.

In Bayou Saint Denis there is at present a 4-foot channel at low-tide, but the distance between 5 feet contours is 5,500 feet.

BAYOU SAINT DENIS.

About 5 miles south of the entrance of Bayou Rigolets, Bayou Saint Denis leaves Little Lake, it being one of the two bayous connecting this lake with Barataria Bay. The length of Bayou Saint Denis is 13 miles, its least width 30 feet, greatest 2,670 feet. The general cross-section conveys the idea of a narrow and deep stream flowing in a broad and shallow one. A depth of from 5 to 6 feet could be carried some distance from shore, when it would abruptly increase to 10, 12, and sometimes 25 feet, shoaling up when across the channel with the same abruptness. As this channel follows what might be called the center of the ebb-tidal current, it indicates a much greater power and velocity of current on the ebb-tide than on the flood. A good 10-foot channel can be found in the bayou.

There are two very fine chenieres on the bayou, Saint Joseph and Cutler's, but with these exceptions the banks of the bayou are all sea-marsh, traversed by numerous lagoons and bayous.

One mile from Little Lake, Lake Villars opens directly into this bayou. This is the lake into which the canal from Bayou Rigolets opens. Lake Villars is a circular sheet of water about 2 miles in diameter and has a depth of about 2½ feet at low-tide. Near the commencement of the tenth mile, Bayou Cutler enters from the north. Of this bayou more will be said under its proper head. The thirteenth mile brings us to the head of Barataria Bay, into which Bayou Saint Denis debouches.

BARATARIA BAY.

This large sheet of water covers an area of about 70 square miles, 40 of which were covered by the hydrography of the survey. Its shores are sea marsh cut up by numerous bays, bayous, and lagoons, and in the lower portion of the bay are several islands.

A depth of 5.5 feet at low-tide is available for navigation in the upper portion of the bay, but this depth cannot be carried out of Bayou Saint Denis, the distance between 5 feet contours being 4,000 feet. A good 4-foot channel exists, however, at low tide. In the lower portion of the bay where the tidal currents are more concentrated, is a channel commencing about 10,000 feet south of what are known as the Middle Banks, said channel deepening continuously to Grand Pass, which has a depth of 44 feet.

The character of the bottom is very similar to that of Little Lake, but in places it is composed entirely of shells. Several shell islands are to be found in the bay, formed probably of the *débris* of the oyster reefs which formerly existed in this locality.

Grand Pass enters the Gulf of Mexico between Grand Terre and Grand Isle. Through it Barataria Bay, as well as the other bodies of water mentioned in this report, are connected with the Gulf. A depth of 44 feet can be found in the Pass, but this depth decreases to about 6 feet at low-tide on the bar in the Gulf. In 1842 the width of the Pass was approximately 6,340 feet, while at present it is but 1,600 feet, showing a decrease of 4,740 feet in thirty-eight years. This advance of shore line seems to have taken place almost altogether on the Grand Isle side of the Pass. An exact comparison cannot be made, but as the extreme depth shown on the chart of 1842 is the same within a few feet as at present, it would seem to indicate a proportional decrease in the volume of water entering and leaving the Pass.

In connection with this it may be stated that over the whole area covered by the survey there seems to be a general tendency of the banks to encroach the water-ways adjacent.

The average range of the tide in Barataria Bay is 1.4 feet, but this tide is greatly affected by the winds. In winter northers sweep over the bay with great violence, making it too rough to allow small craft to cross. Your assistant was not able to sound under full sail once during the entire work, from one to two reefs being constantly carried. On one occasion all the triangulation stations were blown down, thereby greatly delaying the work.

BAYOU CUTLER.

Careful examinations of this bayou and also of Bayou Dupont were made by your assistant, in connection with a possible improvement of the route between New Orleans and Grand Pass.

Bayou Cutler is one of the tributaries of Bayou Saint Denis, flowing into it at Cutler's Chenière, 4 miles from Barataria Bay. The examination was carried up Bayou Cutler to its source, or where it is lost in numerous lagoons and small bayous, through

which it is connected with the lower portion of Bayou Dupont or Smuggler's Bayou. It is a straight, wide, and deep bayou for 5 miles above its mouth, having a least depth of 8 feet and least width of 150 feet, after which it abruptly contracts to a width of 50 and depth of 5 feet for a distance of 3,000 feet, the end of the examination line. There is a good 5-foot channel into Bayou Saint Denis.

It is a sea-marsh bayou, the immediate banks being from 1 to 2 feet high, with a heavy growth of live oaks upon them.

At present the tidal currents are very strong in the bayou, caused by the large reservoir capacity of the lagoons at its head.

The bends are long and gentle, and it is deep from bank, with no obstructions that it would be necessary to remove.

BAYOU DUPONT,

or Smuggler's Bayou, leaves Bayou Barataria at the same point as Bayou Rigolets, and a careful examination of it was made for a distance of 5½ miles.

From this point it continues on in a general southeasterly course until, after passing through numerous lagoons, it enters Barataria Bay.

For the first 2 miles Bayou Dupont passes through a strip of high land known as Cheniere Trouvere.

The banks average about 2 feet in height, and the eastern bank has a heavy overhanging growth of live oaks.

The width averages 125 feet by a depth of 6 feet.

From the second mile to the end of the examination line it widens out, attaining an extreme width of 400 feet, but the depth decreases, so that in places there are but 3 feet of water, and when it attains its extreme width but 2 feet. The bottom is, however, exceedingly soft, consisting chiefly of rotten vegetation.

The weeds and grass in this portion of the bayou point to the fact that, if but let alone, its entire closure is but a matter of short time. It was noted that during a falling tide the current was very slight, and this slight current flowed towards Bayou Barataria instead of, as would naturally be supposed, flowing toward Barataria Bay, the natural outlet of the bayou. This abnormal condition of affairs must be caused by the obstructed condition of the bayou below the point where the examination terminated.

Should it be desirable to utilize this bayou for navigation, numerous overhanging trees and a few snags would have to be removed in the first 2 miles, at the end of which a cut would have to be made through a point where an abrupt bend exists.

In the latter 3½ miles some dredging would be necessary to procure a 5-foot channel.

BAYOU ANDRÉ.

I have no reason to amend my previous report on this bayou, and the conclusions in it comprise all that the examination shows. Its relation to the general improvement of these several bayous and bays is shown in that report.

COMPANY'S CANAL, ETC.

In returning to New Orleans, your assistant passed through the company's canal and its connecting bayous, and made a running reconnaissance of same.

This canal leaves the Mississippi about 3 miles above Harvey's. It has a brick lock at its head which has repeatedly excited remark as about the only construction of its kind in this section that has withstood the test of years without apparent injury.

From this lock a canal about 1½ miles long, with a width of 30 and a depth of 3 feet, connects with the head of Bayou Legnet, a bayou of at first about the same width and depth as the canal, gradually enlarging to Bayou Bordeaux, which latter bayou opens into Lake Salvador. Bayon Legnet is very crooked, naturally, and cut-off canals have been constructed at various bends.

At the mouth of Bayou Bordeaux in Lake Salvador there formerly existed a shell bar, through which a channel has been dredged, but it is filling up again and will soon be obliterated.

Lake Salvador is a sheet of water covering an area of about 70 square miles and has an average depth of 8 feet.

Vessels have a choice of two routes from this lake to Barataria Bay.

Through Bayou Villars into Bayou Barataria, thence to Bayou Rigolets and to Little Lake, or through Bayou Perot to Bayou Rigolets and to Little Lake.

Sailing vessels have a preference for the company's canal, as very little timber is to be found on the banks of the bayous leading to it, and the wind being unobstructed they are enabled to sail almost to the canal.

COMMERCE.

The importance of the improvement of the various bodies of water covered by this survey is contingent.

Should the company now engaged upon the work complete the communication by canals between Barataria Bay and the Atchafalaya River, these bayous and lakes will be of importance as the last links in the chain of communication with the city of New Orleans.

It is expected that a large proportion of the produce of the parishes of Terrebonne, Saint Mary, Iberia, Saint Martin's, Lafayette, Vermillion, and Lafourche would be brought to New Orleans by this route.

The amount is roughly estimated at 46,000 hogsheads of sugar, 81,000 barrels of molasses, and 14,000 barrels of rice.

At present quite a large fleet of luggers are employed in various trades on these bayous and lakes.

A small steamer carries a tri-weekly mail to Grand Isle and Fort Livingston, and a larger boat makes occasional trips for the purpose of carrying supplies to the various plantations and bringing their produce to New Orleans.

In summer a steamboat is put in the trade for the purpose of transporting freight and passengers to Grand Isle during the watering place season.

The commerce to be benefited by any considerable improvement is as before remarked contingent. Should the improvements projected and under way be carried out, competition with other routes will be established at various points, and the population benefited accordingly.

It should be recollected that most of these improvements are in private hands, and that these parties expect to derive a revenue from their investments.

METHODS OF IMPROVING NAVIGATION.

To procure 5-foot navigation from New Orleans to Barataria Bay, two plans are presented:

The first would follow (with the exception of Harvey's Canal) naturally navigable waters, viz: Harvey's Canal, Bayou Barataria, Bayou Rigolets, Little Lake, and Bayou Saint Denis, to Barataria Bay, and would call for the following improvements: Clearing Bayou Barataria of overhanging trees and snags, and possibly two cuts through abrupt bends, dredging a 5-foot channel for 8,500 feet through Pointe le Garde Bar at the head of Little Lake, and also for 5,500 feet across the flat at the foot of the lake into Bayou Saint Denis, together with a slight cut for 4,000 feet at the mouth of Bayou Saint Denis, to meet deeper water in Barataria Bay.

The second route would be via Harvey's Canal, Bayou Barataria, thence down Bayou Dupont for 5½ miles and by a canal, 25,690 feet long, across the sea marsh to the head of Bayou Cutler, down this latter bayou to Saint Denis and to Barataria Bay.

This route would require the removal of overhanging trees and snags in Bayou Barataria, and the same for 2 miles in Bayou Dupont, a cut across a point at an abrupt bend in the latter bayou, and some dredging for the latter 3½ miles; a canal across the sea marsh to the head of Bayou Cutler, and the same cut as in the first route at the mouth of Bayou Saint Denis.

As between the two routes the first is evidently the cheapest in regard to first cost, but it is not likely to be a permanent improvement, as all the cuts will be in open water, and unless protected would be likely to fill by the action of the waves.

Furthermore this route is a circuitous one, the distance between two certain points being 26 miles, while by route No. 2 it is but 16 miles.

By route No. 2, 10 miles of distance are saved, and the canal through the sea marsh can reasonably be regarded as permanent, in proof of which fact the present canal between Bayou Rigolets and Lake Villars has not deteriorated, it is said, since its completion.

The bottom is hard, showing no traces of deposit, and there are no indications of the banks having caved in. It is reasonable to suppose that the increased tidal current caused by the canal in Bayou Dupont would scour it out. The ebb-tide setting down Bayou Barataria would naturally seek the shortest route to the Gulf, which would be through Bayou Dupont, the proposed canal, and Bayou Cutler.

The great length of canal to be cut is rather against this route, but as the country traversed is altogether open sea marsh, averaging 1 foot above low-tide, it would not be expensive in comparison with the generality of such works.

The following estimates for obtaining a channel 50 feet wide and 5 feet deep are submitted:

ROUTE NO. 1.

Bayou Barataria, clearing of snags and overhanging trees, 11 miles, at $200 per mile	$2,200 00

Pointe le Garde, line A B on chart, dredging channel 8,500 feet long, 40,833 cubic yards excavation, at 25 cents	$10,208 25	
Head of Bayou Saint Denis, line C D on chart, dredging channel 5,500 feet long, 10,185 cubic yards excavation, at 25 cents	2,546 25	
Mouth of Bayou Saint Denis, line E F on chart, dredging channel 4,000 feet long, 7,407 cubic yards excavation, at 25 cents	7,851 75	
		76,806 25
Add 10 per cent. for contingencies		7,680 62
Total		78,486 87

On this route the cut across Pointe le Garde Bar, line A B on chart, is the most essential work. The other two cuts are to obtain 5 feet navigation at low-tide, for at both places with an average tide there is a 5-foot channel.

ROUTE NO. 2.

Bayou Barataria, clearing as before	$2,200 00	
Bayou Dupont, clearing out snags and overhanging trees for 2 miles, at $200 per mile	400 00	
Cutting canal across point, end second mile, Bayou Dupont, marked I on chart, 12,963 cubic yards, at 25 cents	3,240 75	
Dredging at various points in Bayou Dupont, between I and G on chart, about 20,000 cubic yards, at 25 cents	5,000 00	
Canal, G H on chart, connecting Bayous Dupont and Cutler, 25,690 feet long, 342,533 cubic yards, at 25 cents	85,633 25	
Mouth of Bayou Saint Denis as before	7,851 75	
		98,325 75
Add 10 per cent. for contingencies		9,832 57
Total		108,158 32

On this route the clearing out of Bayou Dupont and the canal G H are necessary to the obtaining of a 5-foot channel at any stage of the tide.

The material to be dredged in Bayou Dupont is a very soft mud, but with this exception all dredging would be through a tolerably firm, sticky clay with a slight admixture of shells.

In estimating for the canal through the sea marsh a 60-foot cut was allowed for, experience in sea-marsh canals showing that after the banks have assumed their natural slope there will be a 50-foot water way.

A very wide berme would have to be allowed, as this material when first excavated is semi-fluid, though when dry hard enough for a tow-path.

From an inspection of the accompanying index chart it will be seen that any improvement below Bayou Villars will be of equal benefit to either of the canals now connecting with the Mississippi River; and, also, that such improvement is but a connecting link between canals and cuts owned and operated by private corporations.

The field work of the survey has been plotted on four large sheets. One index chart, showing comparative soundings between survey of 1842 and recent one, accompanies this report.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

2.

NEW ORLEANS, LA., *April* 23, 1881.

SIR: None of the canals so far as I could ascertain publish a regular schedule of rates.

The following is a list of charges as obtained from parties residing at the head of Harvey's and Company's Canals and from various lugger men.

COMPANY'S CANAL.

Any skiff or small boat passing lock	$0 75
Large boats, per ton, passing lock	50

HARVEY'S CANAL.

During marine railway:	
Each skiff over railway	$0 25
Each skiff through canal	25
Large boats over railway, per ton	25
Large boats through canal, per ton	25
South Louisiana Canal and Navigation Company:	
Per ton through canal from Caminada Bay to Bayou Lafourche	35
Per ton through canal from Bayou Lafourche to Terrebonne	15

Respectfully,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL.

APPENDIX N.

IMPROVEMENT OF SABINE PASS AND BLUE BUCK BAR, AND OF THE SABINE AND NECHES RIVERS, TEXAS.

REPORT OF CAPTAIN CHARLES E. L. B. DAVIS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881.

UNITED STATES ENGINEER OFFICE,
Sabine Pass, Tex., July 19, 1881.

GENERAL: I have the honor to forward herewith annual reports of the works under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF SABINE PASS AND BLUE BUCK BAR, LOUISIANA AND TEXAS.

During the fiscal year ending June 30, 1873, an examination of the pass was made and a report forwarded to the Chief of Engineers.

Under instructions from the Chief of Engineers the officer then in charge of the work submitted, in February, 1875, a report with plan and estimates "for the improvement of the navigation of the harbor and bar at Sabine Pass, Texas."

By act of Congress approved March 3, 1875, $20,000 were appropriated for the work. The work was let out at contract, but owing to the failure of the contractors the contract was annulled.

Under the act approved August 14, 1876, $38,000 were appropriated and bids were invited for the work, but as the lowest bid would not complete a channel of 12 feet, all bids were rejected and the United States dredge-boat Essayons was put at work to dredge the channel.

This boat, after half completing a channel of from 12 to 15 feet across the bar, became disabled and had to be sent to New Orleans for repairs. In August, 1878, she returned to Sabine Pass and worked until February, 1879, when operations were suspended and the boat laid up at New Orleans; during this time she was occupied in dredging a channel across the outer bar, and also in cutting a channel through the shell reef that separated the harbor of Sabine from the roadstead inside of the outer bar.

During the fiscal year ending June 30, 1880, the dredge-boat remained at New Orleans, as the amount of money available was not considered sufficient to resume operations.

A further appropriation of $50,000 was made by act of Congress approved June 14, 1880, for improving Sabine Pass and Blue Buck Bar. This, with the balance remaining unexpended, was considered sufficient for resumption of work.

After thoroughly repairing the dredge-boat Essayons she was sent to Sabine Pass, where she arrived September 20, 1880.

On her arrival the master of the Essayons reported that he sounded for two hours below the wreck Clifton, but could not find any trace of the channel previously dredged. During the time from her arrival in September to the end of the fiscal year ending June 30, 1881, the Essayons worked only about 482 hours, consuming 1,484 tons of coal.

On the 21st of June, 1881, soundings taken on the bar showed a channel of about 12 feet, though it was narrow and difficult to find.

In the monthly report of operations for April, 1881, the officer in charge states:

> The reports for April serve to confirm my impression, at the beginning of the month, that the dredge will very soon be disabled and forced to return to New Orleans for laying up or for repair.

The small amount of work done during the year by the Essayons, together with the causes thereof, was made the subject of a special report to the Chief of Engineers under date of June 24, 1881, with the recommendation that the boat be laid up for the present.

Coming to this station so late in the fiscal year (June 16, 1881), I have not had time to prepare a plan of improvement with detailed estimates of cost, but a plan was being prepared by Capt. D. W. Lockwood, under the direction of Maj. C. W. Howell, which contemplated two jetties, whose aggregate length was about 5 miles, the approximate cost of which was about $1,700,000, and in the absence of any estimate of my own, I respectfully submit these figures.

The work is situated in the collection district of Galveston. The nearest light-house is situated on Louisiana Point, just inside the entrance of the pass.

COMMERCIAL STATISTICS.

Mr. S. C. Arledge, deputy collector of customs at this place, has kindly furnished me with the following commercial statistics for the fiscal year:

Number of steam vessels arrived	27
Number of steam vessels departed	27
Tonnage, 2,119 tons.	
Number of sailing vessels arrived	174
Number of sailing vessels departed	174
Tonnage, 4,659 tons.	
Value of domestic imports and exports, $89,510.	

Total amount appropriated	$313,000 00
Total amount expended	153,023 88

Money statement.

July 1, 1880, amount available	$64,775 14	
Amount appropriated by act approved March 3, 1881	150,000 00	
		$214,775 14
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	41,837 09	
July 1, 1881, outstanding liabilities	12,961 93	
		54,799 02
July 1, 1881, amount available		159,976 12
Amount that can be profitably expended in fiscal year ending June 30, 1883		250,000 00

N 2.

IMPROVEMENT OF SABINE RIVER, LOUISIANA AND TEXAS.

This improvement having been under the charge of Maj. S. M. Mansfield during the entire fiscal year, except a few days in June, attention is invited to the annual report of that officer (Appendix O 1).

N 3.

IMPROVEMENT OF NECHES RIVER, TEXAS.

As in the case of Sabine River, this improvement having been under the charge of Maj. S. M. Mansfield during the entire fiscal year, except a few days in June, attention is invited to the annual report of that officer (Appendix O 2).

APPENDIX O.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATE OF TEXAS.

REPORT OF MAJOR S. M. MANSFIELD, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., August 5, 1881.

GENERAL: I have the honor to forward herewith my annual reports relating to the works of river and harbor improvements under my charge for the year ending June 30, 1881.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Colonel, U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 1.

IMPROVEMENT OF SABINE RIVER, TEXAS.

Survey of mouth of the river was made in 1871. (See Report of the Chief of Engineers, 1871, pages 540–43.)

Survey of the bar at the mouth and of the main channel of the river to Belzoria, Tex., was made in 1872–1873. (See Report of the Chief of Engineers, 1873, pages 680–84.)

Re-survey of the river from its mouth to East Hamilton was made in 1879. (See Report of the Chief of Engineers, 1880, pages 1195–1200.)

Appropriation of 1878, $10,000, was for improving the Narrows above Orange, Tex., and deepening the channel at the mouth of the river, and it was applied to dredging a channel across the bar at the mouth.

Appropriation of 1879, $6,000, was for improving the Narrows and deepening channel at the mouth, and is to be applied to improving the Narrows.

Appropriation of 1880, $5,000, was for improving the Narrows and deepening channel at the mouth, and is to be applied to widening and deepening the channel across the bar at the mouth of the river in conjunction with the—

Appropriation of 1881, $7,000, was for improving the Narrows and and deepening the channel at the mouth of the river.

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1881.

In response to advertisement (re-advertisement for bids covering work on cut-off and removing logs and snags) of July 8, proposal was received from David R. Wingate, of Orange, Texas, for doing the work, viz, at an aggregate cost of $9,000 for improving the Narrows in conformity with the specifications.

This proposal was not considered satisfactory, and was rejected; and in accordance with a memorandum agreement the proposal of Mr. F. A. Hyatt (a formal bidder under advertisement of May 25) was by authority accepted, viz, $2,100 for the cut-off and $400 per mile for removing snags, &c., total $4,100, work to be completed by June 30, 1881. Articles of agreement were dated September 11, 1880.

But very little was accomplished under this contract during October, November and December, 1880, in consequence of rainy weather and the rise of water in the river; and in January, 1881, in conformity with the wishes of manufacturers and parties directly interested in that portion of the Sabine known as the Narrows, the contract of September 11, 1880, was modified in the following manner: The cut-off from Main River into the Narrows to be 75 feet instead of 35 feet; and another cut-off to be made at Dead Bend in lieu of removing the logs, snags, &c., from the bed of the stream around that bend. This modification increased the amount to be paid under the contract $1,850, or a total of $5,950 when the work shall have been completed according to agreement. Date of modified articles January 17, 1881.

Up to and including June 13, 1881 (the date of transfer of this improvement to Capt. Charles E. L. B. Davis, Corps of Engineers, pursuant to paragraph 13, Special Orders No. 120, Headquarters of the Army, A. G. O., May 26, 1881), the work accomplished by Mr. Hyatt, the contractor, was:

1. The cut-off at the head of the Narrows had its entire ground, including 50 feet on each side of the cut, cleared and the earth removed to a depth of from 16 inches to 5 feet over the area of the proposed cut-off.

2. The cut-off at Dead Bend was almost completed; a few yards of earth will have to be removed from the entrance to the channel (now over 50 feet wide at its narrowest point), the rest of the cut (except at its upper end) being full 60 feet wide.

Mr. Hyatt, in a communication requesting an extension of time in which to complete his work, says that he has been forced to abandon the work on the Narrows three times on account of high water, and has not attempted to resume work, for the reason that the water does not remain low long enough at this season of the year (spring and early summer) to make such work practicable.

There having been no complaints of the navigation of the Narrows this season owing to high-water, the application for extension of time beyond June 30, 1881, asked for has received recommendation.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

On the 30th of March, 1881, a project was forwarded, recommending the expenditure of the available funds (appropriations of 1880–1881), $12,000, in deepening and widening the channel at the mouth of the river, estimated excavation 40,000 cubic yards, to be done by contract after inviting proposals.

An advertisement, bearing date of May 14, 1881, invited proposals for the improvement mentioned.

The following is an abstract of bids received in response to the advertisement:

Abstract of proposals for improving Sabine River, Texas, in response to an advertisement dated May 14, 1881, *and opened June* 13, 1881, *by Major S. M. Mansfield, Corps of Engineers.*

No.	Bidders.	Dredging.
		Per cu. yd.
1	John Maguire	*$0 34.9
2	Jas. E. Slaughter	37
3	G. L. Long	40

*Lowest responsible bidder. Agrees to commence work within six months after receiving notice of acceptance of his bid, and to complete it within one year.

The abstract, together with bids, &c., was transmitted to Captain Davis, June 13, for his action.

ORIGINAL ESTIMATES.

Work at mouth (report of 1871)	$38,000
Removing snags, &c. (report of 1873)	18,000
Work on the Narrows (report of 1880)	17,500

Fourteen thousand dollars is asked for the next fiscal year, 1882–'83' to continue improvements in accordance with plans heretofore submitted. The estimated amount required for completion of the work projected is simply conjectural, the work not being considered susceptible of permanent completion, and requiring modification in the application of the funds from time to time.

The work is located in the collection district of Galveston. The nearest light-house is at Sabine Pass.

Money statement.

July 1, 1880, amount available	$11,017 87	
Amount appropriated by act approved March 3, 1881	7,000,00	
		$18,017 87
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		82 03
July 1, 1881, amount available		17,935 84
Amount that can be profitably expended in fiscal year ending June 30, 1883.		14,000 00

COMMERCIAL STATISTICS FURNISHED BY D. R. WINGATE, ORANGE, TEXAS, JUNE 30, 1881.

Steamboats running on the river, 5, with an ordinary draught of 4 feet; other boats having a tonnage in the aggregate of about 1,500 tons.
Bales of cotton shipped at points along the river, 12,000.
Logs of cypress, pine, &c., cut in the vicinity of the river, 35,000,000 feet, B. M.
Lumber shipped from Orange, 30,000,000 feet, B. M.
Shingles (cypress) from Orange, 30,000,000.

Yours, truly,

D. R. WINGATE.

Maj. S. M. MANSFIELD.

O 2.

IMPROVEMENT OF NECHES RIVER, TEXAS.

Survey (of the Neches and Angelina Rivers) was made in 1872–'73. (See report of the Chief of Engineers, 1874, pages 743–54.)

Re-survey of the Neches River from its mouth to Bevilport was made in 1880. (See report of the Chief of Engineers, 1880, pages 1202–1204.)

Appropriation of 1878, $8,000, was for deepening the channel at the mouth of the river and removing obstructions to Beaumont, and was applied to dredging channel across the bar at the mouth.

Appropriation of 1879, $5,000, was for "improving mouth of Neches River," and was applied to deepening and widening the channel over bar at the mouth.

Appropriation of 1880, $5,000, was for improving Neches River, continuing operations, and is to be applied in removing snags, logs, and overhanging trees between Yellow Bluff and Bevilport in conjunction with the appropriation of 1881, $3,000, which was for improving Neches River.

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1881.

Active operations in improving the river were suspended during the entire year for want of sufficient funds, the estimate (report of the re-survey of 1880) for removing snags and overhanging trees between Bevilport and Yellow Bluff being $15,000, $10,000 more than the appropriation available.

PROBABLE OPERATIONS OF THE YEAR 1882.

After notification of the approval of the river and harbor act of 1881, and in compliance with directions for the forwarding of a project, a report was rendered March 30, 1881, covering a project for the expenditure of the $8,000 available of the appropriation of 1880–'81, viz: To remove snags, logs, and overhanging trees along the distance from Yellow Bluff up the river towards Bevilport, the work to be done by contract after inviting proposals.

An advertisement bearing date May 14, 1881, invited proposals for the improvement mentioned.

The following is an abstract of bids received in response to the advertisement:

Abstract of proposals for improving the Neches River, Texas, in response to advertisement dated May 14, 1881, and opened June 13, 1881, by Maj. S. M. Mansfield, Corps of Engineers.

No.	Bidders.	Improving navigation of the river.
1	Joseph Grigsby Smyth	At a total of $7,500.
2	Allen A. Neyland and James C. Henderson	*At a total of $7,465.50.

* Lowest responsible bidders.

The abstract, together with bids, &c., was transmitted to Capt. Chas. E. L. B. Davis, Corps of Engineers, June 13, for his action, Captain Davis

having been assigned to the charge of this improvement (relieving me June 13) by paragraph 13, Special Orders No. 120, Headquarters of the Army, A. G. O., May 26, 1881.

ORIGINAL ESTIMATES.

Dredging channel at mouth (1874)	$26,318 05
Removing snags, &c., between Bevilport and Yellow Bluff (1880)	15,000 00

Eighteen thousand three hundred and eighteen dollars and five cents, the amount remaining of former estimates, can be profitably expended in continuing operations in the fiscal year ending June 30, 1883.

The work is not considered as susceptible of permanent completion, and the estimates, from time to time, will vary.

The work is located in the collection district of Galveston. The nearest light-house is at Sabine Pass.

Money statement.

July 1, 1880, amount available	$5,107 30	
Amount appropriated by act approved March 3, 1881	3,000 00	
		$8,107 30
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		99 74
July 1, 1881, amount available		8,007 56
Amount that can be profitably expended in fiscal year ending June 30, 1883		18,300 00

COMMERCIAL STATISTICS.

BEAUMONT, TEX., *June* 27, 1881.

DEAR SIR: Your favor 23d instant received, and we will reply as well as we can to your interrogatories, but really feel unable to do the subject justice.

STEAMBOATS.

At this season of the year we hardly ever have more than one steamboat running in this river, and that only to "Weiss Bluff," and occasionally a trip to Sabine Pass. However, there is a demand for at least three steamboats in the Neches River trade during the high-water season, say from 1st October until 1st of May. At present there is only one boat in service.

The boats best suited for the business on this river are light-draught; a boat that will not draw over 6 feet loaded with 1,000 bales of cotton. The boats that have been running up this river of late years are all rather small to what were formerly used. There is plenty of water for larger boats whenever the river is up, as it usually is in the winter months.

The greatest obstacles are snags and sunken timber.

We think that with a good crop and a clear river, for the boats to go up above Bevilport, on the Angelina, at least 10,000 bales of cotton would find its way to market down this river; and with a harbor at Sabine Pass for large ships the amount of business would be materially increased.

PINE LOGS.

The present cutting and running of pine logs down this river has been very limited, owing to the same obstructions, in part.

The steamboats have to contend with snags and sunken timber; but, with the proper clearing out of the river, pine saw-logs and railroad ties could be floated down the river at most all seasons of the year, and it would cause the limited amount now to rapidly increase.

The average amount of logs floated will approximate, say, about 2,000,000 feet per

month. We put in at Yellow Bluff now an average of 1,000,000 feet per month, and there is a large amount floated out of Village Creek, in Hardin County, coming into the river in tide-water, below Weiss Bluff.

LUMBER.

Shipments of lumber from Beaumont will average about 40 cars per day of 6,000 feet each; total per day, over 200,000 feet. And with a clean river and plenty of logs to keep all the mills running, the shipments would be at least 50 per cent. more.

It is very frequently the case that our mills have to stop for want of logs.

Cypress logs are obtained only during high-water, in the fall, winter, and spring. We have been short of cypress timber for two years, but manage to get enough to make from 30,000,000 to 40,000,000 shingles a year, though not enough to supply the demand, or to keep our mills running longer than eight months during the last year.

Our river ought to have all the obstructions removed from Weiss Bluff up to and above Bevilport.

Yours, truly,

LONG & Co.

Maj. S. M. MANSFIELD.

O 3.

IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, TEXAS.

Survey of this harbor and entrance was made in 1868. (See Report of Chief of Engineers, 1868, pages 497–517.)

Survey of the harbor and its approaches was made in 1873. (See Report of Chief of Engineers, 1874, pages 722–728.)

Intermediate surveys have been made covering the area of the inner bar, of the outer bar, and of the outer gabionnade and its immediate vicinity; also of the brush mattress jetties and immediate vicinities.

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1881.

The work on the south jetty was begun in July, the point selected for commencement of the work being located 3,300 feet from the outer end of the Fort Point gabionnade in 6 feet water.

The work has been carried on by hired labor and by purchase of material in part by contract and in part in open market.

The following is an abstract of proposals received for furnishing material (for Galveston Harbor), in response to advertisement dated December 16, 1880, and opened January 13, 1881:

Abstract of proposals for furnishing material (for Galveston Harbor), in response to advertisement dated December 16, 1880 (*copy attached*), *and opened January* 13, 1881, *by Maj. S. M. Mansfield, Corps of Engineers.*

No.	Names of bidders.	Brush, 6,000 cords.	Cane, 1,000 cords.	Ratline, 35,000 pounds.	Manilla, 3,400 pounds.	Stone, 6,000 cubic yards.	Remarks.
		Per cd.	*Per cd.*	*Per lb.*	*Per lb.*	*Per c.y.*	
1	Shannon and Hyatt	$4 50	$6 00	.....	.....	.....	
2	Rosamond, Milam & Brother	6 00	.....	.....	.....	.....	
*3	J. Anderson	4 00	5 50	.....	.....	.....	No bond.
4	F. W. Henricks	.....	6 75	.....	.....	.....	
*5	H. Marvitz & Co	.....	.....	$0 11	$0 12	.....	No bond.
6	Theo. K. Thompson	.....	.....	11.4	12	.....	
7	The Gulf, Colorado and Santa Fé Railroad.	.....	.....	.....	.....	$4.95	If reached by railroad.

*3 and 5, informal; 2, 4, and 7, rejected; 1 and 6, contracts recommended.

The contracts were awarded to Theo. K. Thompson (cordage), February 4, 1881; Shannon & Hyatt (brush), February 12, 1881; Gulf, Colorado and Santa Fé Railroad (stone), February 18, 1881; and a proposition from Munn, Fry & Co., of Galveston, to do the work of unloading stone from cars, and to load our barges, was accepted (after approval), viz, to unload cars, 12 cents per cubic yard; to load barges, 28 cents per cubic yard.

An advertisement, bearing date May 12, 1881, invited proposals for cordage, brush, cane, and stone. The following is an abstract of bids received in response thereto (under appropriation of 1881, $250,000):

Abstract of proposals for furnishing material (Galveston Harbor), in response to advertisement, dated May 12, 1881, and opened June 1, 1881, by Maj. S. M. Mansfield, Corps of Engineers.

No.	Bidders.	Ratline, 40,000 pounds.	Lath-yarn, 9,000 pounds.	Rope, 9,000 pounds.	Thimbles, 2,200 pounds.	Brush, 16,000 cords.	Cane, 2,300 cords.	Stone, 18,000 tons.	Amount.
		Per lb.	*Per lb.*	*Per lb.*	*Per lb.*	*Per cd.*	*Per cd*	*Per ton.*	
1	C. D. Holmes	$0 11.	$0 9½	$0 14½	$0 15	.....	.....	.....	$6,890 00
2	B. F. Disbrow	10.90	9	13.80	9⅞	.....	.....	.....	6,629 25
3	H. Marivitz & Co	10.15	8.9	13.15	11¼	.....	.....	.....	6,292 00
*4	Theo. K. Thompson	9.9	8¾	13¼	12	.....	.....	.....	6,204 00
5	Woodward & Wight	10¾	.....	13¼	13½	.....	.....	.....	
6	Waters S. Davis	11½	9½	13¾	10½	.....	.....	.....	6,923 50
7	Adolph Flake & Co	10¾	10½	13½	11	.....	.....	.....	6,702 00
*8	Shannon & Hyatt	.....	.....	.....	.....	$4 50.	$5 75	.....	85,225 00
9	Robert A. Milam, James M. Heiskell	.....	.....	.....	.....	5 50	6 50	.....	102,950 00
*10	Gulf, Colorado and Santa Fé Railroad Co.	.....	.....	.....	.....	.....	.....	$4	72,000 00

* 4, 8, 10 lowest responsible bidders. Contracts recommended.

The proposals of Theo. K. Thompson for cordage, Shannon & Hyatt for brush and cane, and of the Gulf, Colorado and Santa Fé Railroad Company for stone, were accepted; contracts will be entered into immediately.

Great difficulty and delay were occasioned by the want of power in our tow-boat, the Molyneux; against strong tides it was almost impossible for her to tow the mattresses out. Therefore, in the interim, and until such time as a suitable tug could be purchased for the work, authority was asked (and granted) to hire a tug from time to time as required.

On the 14th of April the tug L. B. Coates was engaged to tow mattresses, and was so engaged until the 25th, when relieved by the tug General Stewart Van Vliet; the Van Vliet continuing in our employ until the 18th of May, when relieved by the steam-tug Cynthia (purchased in Philadelphia on the 10th of May for the government work here). The tugs Coates and Van Vliet were hired from the Houston Direct Navigation Company, at the rate of $450 per month; the crews being paid and rationed by the government, and the government furnishing the necessary supplies of coal, water, oil, &c.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Continuation of work on the south jetty to exhaustion of the available funds, the labor being hired, incidentals purchased in open market, and stone, brush, cane, and cordage to be furnished under contract. It is estimated that the following work can be accomplished this fall, using up the funds now on hand, save an amount which will be reserved for care of the plant, &c., during the rest of the fiscal year, or until such time as funds may become available for the work.

The south jetty will be carried out to the crest of the bar with one layer of mattresses 90 to 120 feet in width, and a second tier of mattresses

will be laid for a length of 1 to 1½ miles from the bar inwards, thus raising quickly the jetty to a height of 5 to 6 feet above the sand, when, it is thought, a very appreciable deepening of the water on the bar will result. This can all be accomplished, I trust, in time to have the benefit of the scour due to the fall and winter storms.

Accompanying is a sketch showing a cross-section of the jetty near the outer end. An inspection will show its points of advantage over any section yet devised; it is the suggestion of Superintendent Mr. William W. Burke.

Aside from the great merit of economy in point of material required, it possesses the merit of offering little or no obstruction to the sea. The ends of the mattresses are made thin and kept low, the stone ballast is all deposited in pockets which prevent its displacement and will do away entirely with the use of large stones or blocks of concrete of sufficient weight in themselves to resist the action of the sea, and no paving of slopes is contemplated.

It is easily constructed, and the height of the jetty will be determined by the depth of the water obtained over the bar.

Mr. Burke has been indefatigable in his efforts to prosecute the work rapidly and economically. I am indebted to him for many valuable suggestions.

Extracts from his report are herewith submitted.

The work is now progressing in the most satisfactory manner.

The estimates for the improvement here according to the approved plan is.	$1,825,813
Appropriated	425,000
Unappropriated balance	1,400,813

Of which sum $500,000 could be very profitably expended in the fiscal year ending June 30, 1883, in continuing work on the jetties. (See report of the Board of Engineers, dated November 20, 1880, published herewith.)

The work is located in the collection district of Galveston. The nearest light-house is on Bolivar Point, at entrance to Galveston Bay.

Money statement.

July 1, 1880, amount available	$209,568 29	
Amount appropriated by act approved March 3, 1881	250,000 00	
		$459,568 29
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	184,776 84	
July 1, 1881, outstanding liabilities	10,000 00	
		194,776 84
July 1, 1881, amount available		264,791 45
Amount (estimated) required for completion of existing project		1,400,813 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		500,000 00

REPORT OF MR. WILLIAM W. BURKE, SUPERINTENDENT.

UNITED STATES ENGINEER WORKS,
Galveston, Tex., July 5, 1881.

COLONEL: I have the honor to submit a report of operations on the improvement of harbor at Galveston, Tex., for the fiscal year ending June 30, 1881.

The work consists in the manufacture and placing of mattresses, and in the construction of a suitable plant for this work.

There have been constructed:

3 mattresses 18 by 60 feet by 30 inches over all.



Cross Section of proposed Galveston Jetty now under construction.

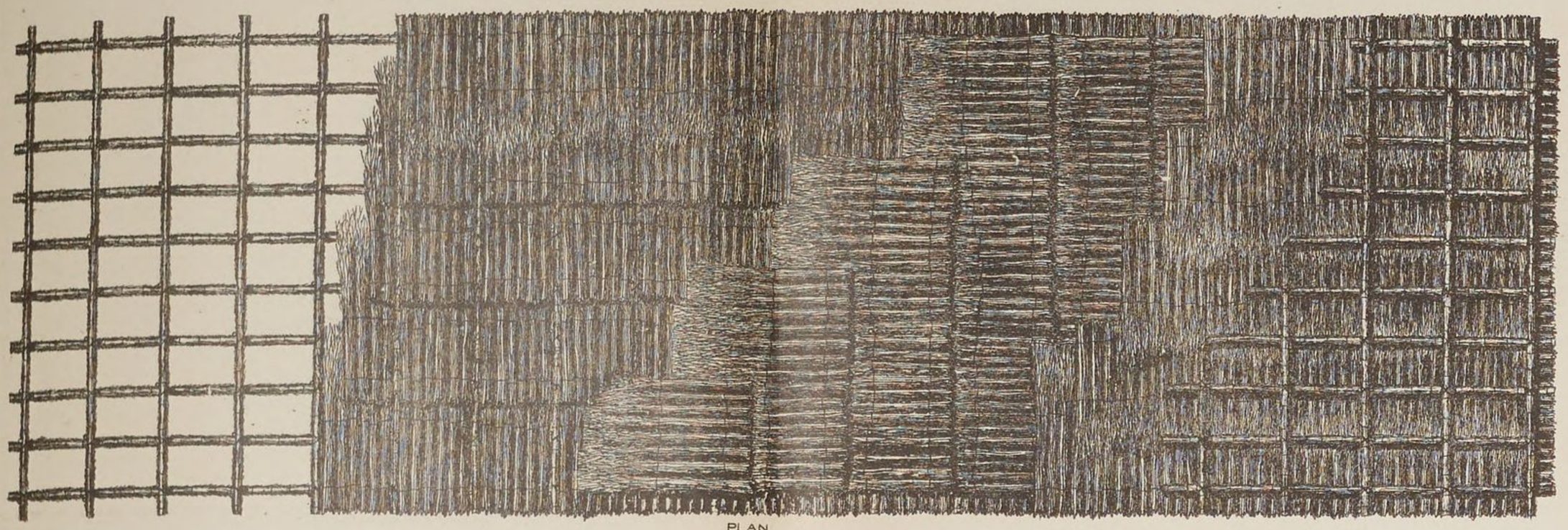
Sketch of Mattress used at Galveston
Showing details of construction
Drawn by
J. M. Picton

MATTRESS
30'x35'



ELEVATION

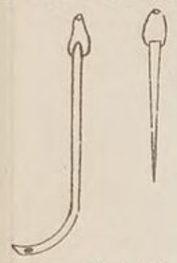
SCALE 1÷72



PLAN

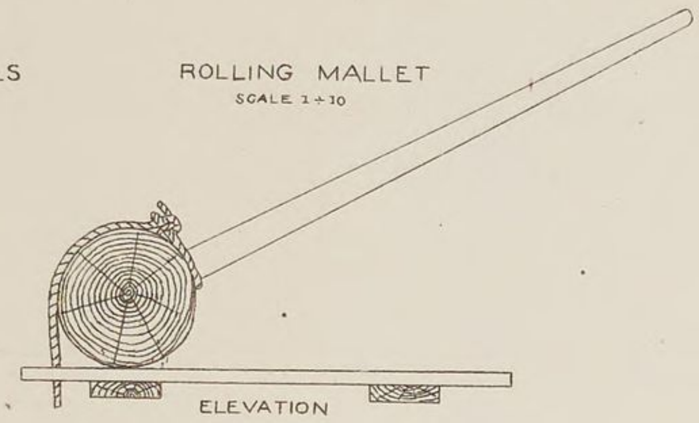
MATTRESS TOOLS

NEEDLE AND MARLINE SPIKE

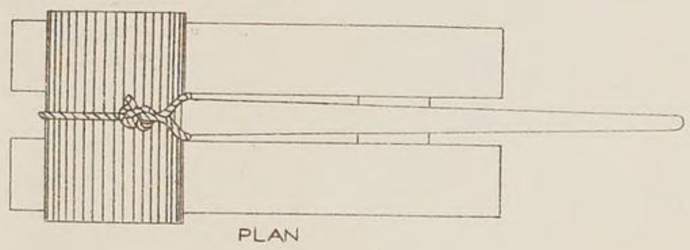


SCALE 1÷12

ROLLING MALLET
SCALE 1÷10

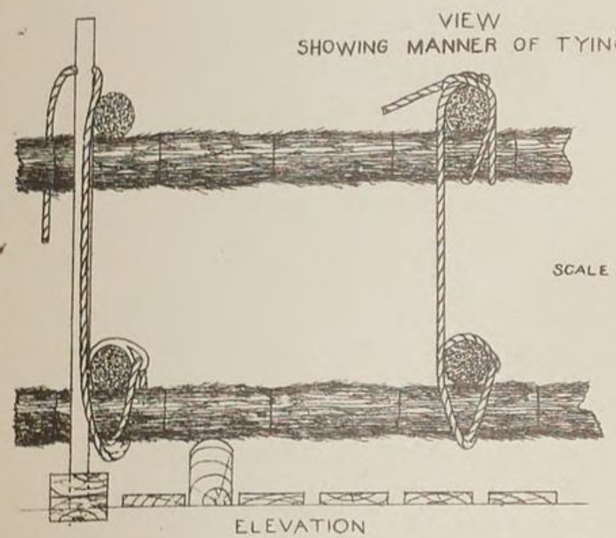


ELEVATION



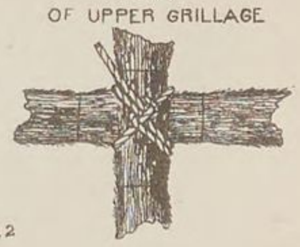
PLAN

VIEW
SHOWING MANNER OF TYING



ELEVATION

PLAN
OF UPPER GRILLAGE



SCALE 1÷12

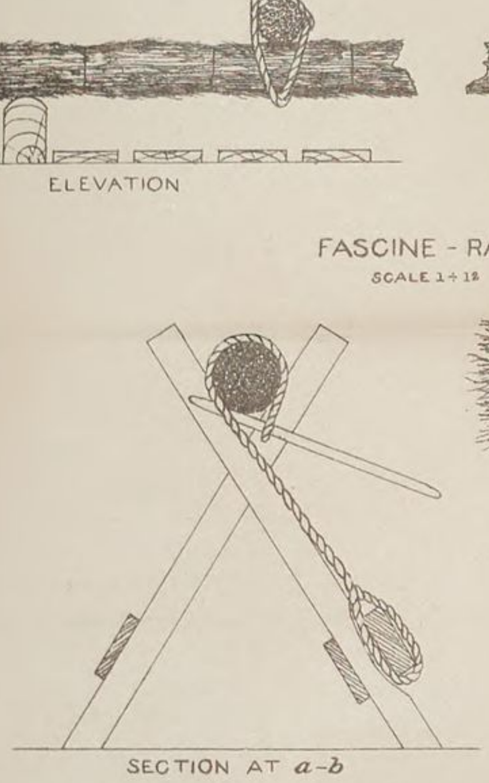


PLAN
OF LOWER GRILLAGE

GENERAL SCALE
1÷144.

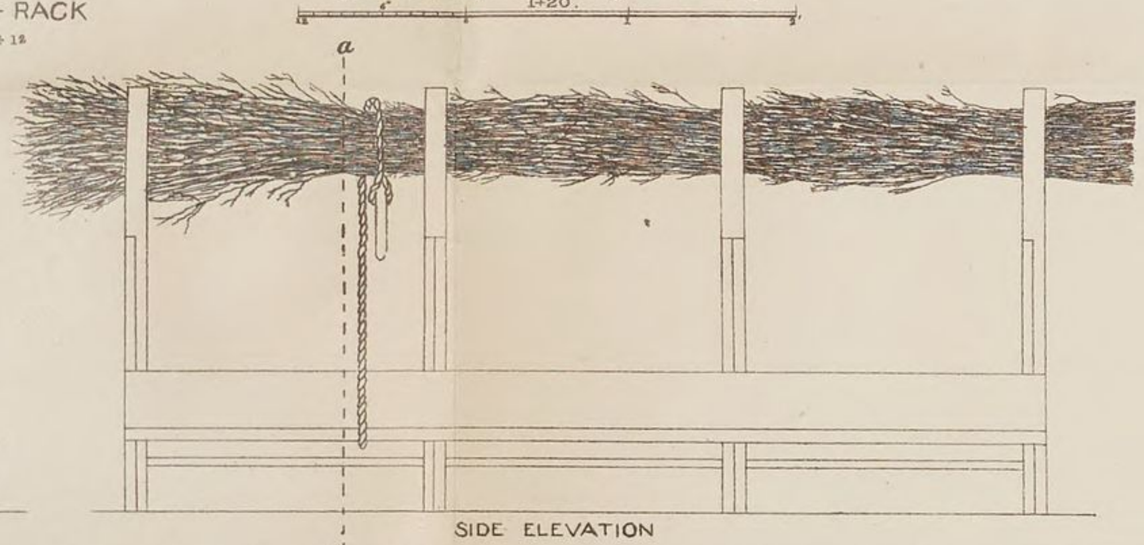
SCALE OF DETAILS
1÷24.
1÷20.

FASCINE - RACK
SCALE 1÷12



SECTION AT *a–b*

a



b

SIDE ELEVATION

51 mattresses 27 by 60 feet by 30 inches over all.
1 mattress 15 by 60 feet by 30 inches over all.
1 mattress 15 by 95 feet by 30 inches over all.
2 mattresses 30 by 60 feet by 30 inches over all.
162 mattresses 30 by 95 feet by 30 inches over all.

There has been placed on line of north jetty 90 linear feet, 60 feet wide, averaging in height above sand bottom with ballast, 2½ feet.

On line of south jetty in water from 6 to 13 feet deep, 5,846 linear feet, 60 feet wide and 2½ feet high, and 1,981 linear feet 90 feet wide and 2½ feet high.

In this work there have been used:

Cords of brush	9,310.96
Cords of cane	865.75
Cubic yards of stone	6,513,839
Cubic yards of concrete	728,566
Pounds of ratline	27,402.5
Pounds of marline	6,662
Pounds of manilla rope	3,966.5
Pounds of thimbles	903
Pounds of lath-yarn	5,466
Oak stakes	5,509

Not one of all the mattresses placed has been lost, and it is believed that with due care we shall meet with no serious loss during the next year.

A part of the old plant used for placing gabions has been repaired to make it serviceable for this work, and in addition, three new barges and one storing and tilting mattress platform, 960 feet long and 75 feet wide, have been constructed, and one tug purchased.

We have now all the plant needed for this work, and are prepared to do a much larger amount of work than has yet been accomplished.

Appended is a statement showing number of working days in each month and work done.

In the prosecution of this work so far, many difficulties have been met with and overcome, and it is believed that now we are in a condition to do the work cheaply and well.

Very respectfully, your obedient servant,

WM. W. BURKE,
Superintendent.

Statement showing number of working days in each month and work done.

Month.	Working days.	Mattresses placed.	Mattresses placed.	Stone or cane placed on mattresses.	Remarks.
1880.	*Number.*	*Days.*	*Square feet.*	*Cubic feet.*	
July	15	5	14,580.00	3,708.55	Concrete blocks.
August	23	3	9,720.00	3,003.00	Do.
September	11	1	3,240.00	990.00	Do.
October	16	6	19,440.00	5,148.00	Do.
November	10	8	25,920.00	7,550 00	Do.
December	15	3	9,720.00	2,735.40	Do.
1881.					
January	12	.....	(*)	(*)	Constructing plant.
February	10	.....	(*)	(*)	Do.
March	12	3	24,600.00	15,174.00	Broken stone.
April	9	8	25,400.00	56,457.00	Do.
May	17	10	166,575.00	72,741.50	Do.
June	14	8	122,550.00	52,007.35	Stone and concrete.
Totals	164	55	521,745.00	219,514.80	

* Out of materials.

COMMERCIAL STATISTICS.

GALVESTON, *July* 8, 1881.

DEAR COLONEL: I find it impracticable to give you an accurate statement of the value of imports, foreign and domestic, for the trade of Galveston for the six months ending June 30, 1881, as many of our merchants do not close their accounts to that date.

From the best information attainable I estimate the increase as compared with the

first six months in 1880 at 30 per cent. For a like reason the value of exports cannot be accurately given to this date.

The collector of customs has kindly furnished me with a statement of customs duties collected, for the six months ending June 30, which enables me to give you the following interesting comparisons:

Total duties fiscal year ending June 30, 1881	$1,473,854
Total duties fiscal year ending June 30, 1880	318,211
Increase equal to 363 per cent	1,155,643
Duties first six months in 1881	888,629
Duties first six months in 1880	205,647
Increase equal to 332 per cent	682,982

A large percentage of the above is derived from duties on rails, but deducting the duties on rails from the total shows an increase of duties on general merchandise, first six months in 1881, over first six months in 1880, of 122 per cent.

Respectfully,

JAMES SORLEY.

STATISTICS OF THE PORT OF GALVESTON, YEAR ENDING DECEMBER 31, 1880.

Exports of domestic produce.

Cotton to foreign ports	$17,318,047	
Cotton to domestic ports	10,977,138	
		$28,295,185
Wool, 20,246 bags		1,836,740
Hides, bales 9,878 bundles 6,955, loose 7,016		2,040,500
Cattle		445,500
Tallow		172,000
Bones		96,000
Horns		55,000
Peltries		140,000
Pecans		47,700
Beeswax		18,264
Hair		6,450
Grain and flour (no wheat)		406,000
Cotton-seed		65,400
Cotton.seed oil		60,120
Cotton seed oil cake		129,300
Sugar		560,000
Molasses		52,400
Total		34,426,559
To foreign ports		17,465 611
To domestic ports		16,960,948
		34,426,559

Increase oves 1879, $2,710,589, equal to 8½ per cent.

Value of imports, foreign and domestic, for the trade of Galveston, for the year ending December 31, 1879, *and* 1880.

Articles.	1879.	1880.
Groceries	$7,813,700	$9,854,094
Dry goods	2,795,000	3,080,000
Notions	661,090	2,047,500
Boots, shoes, and hats	1,785,650	2,295,700
Hardware	704,200	960,500
Clothing	735,000	1,271,455
Crockery and glassware	78,000	84,400
Drugs	200,000	260,000
Lumber, shingles, and laths	225,000	780,000
Wines and liquors	540,000	591,700
Furniture	270,000	291,988
Lime and cement	25,000	45,000

Vælne of imports, foreign and domestic, for the trade of Galveston, &c.—Continued.

Articles.	1879.	1880.
Bricks	$48,000	$27,500
Sash, doors, blinds	147,000	92,000
Paints and oils	92,000	190,000
Iron ties and baling stuffs	997,400	670,000
Coffee, cargoes direct	683,000	338,314
Coal	88,500	200,500
Jewelry	.....	215,000
Music materials	.....	48,000
Ship chandlery	.....	181,000
Cordage	.....	71,500
Wheat, for two mills	.....	450,000
Other grain and hay	.....	650,000
Live stock	.....	350,000
Iron and steel rails and fastenings	340,000	3,776,916
Railroad rolling stock	102,500	310,000
	18,331,040	29,133,067

Increase of 1879 over 1878, 26 per cent. Increase of 1880 over 1879, 59 per cent.

STATEMENT OF DUTIES ON IMPORTED GOODS COLLECTED AT THE CUSTOM-HOUSE, GALVESTON, FOR THE YEAR ENDING DECEMBER 31, 1880, FURNISHED BY ORDER OF HON. E. M. PEASE, COLLECTOR.

January	$6,980 84
February	27,202 14
March	27,521 35
April	4,579 02
May	32,911 73
June	106,451 99
July	89,593 88
August	134,893 08
September	70,307 81
October	127,582 49
November	63,079 63
December	99,768 40
	790,872 36

Increase of 1879 over 1878, 200 per cent. Increase of 1880 over 1879, 515 per cent.
Compiled by—

JAMES SORLEY.

IMPORTS OF MERCHANDISE AT THE PORT OF GALVESTON, TEXAS, FROM JANUARY 1, 1881, TO JUNE 30, 1881.

CUSTOM-HOUSE, GALVESTON, TEX.,
Collector's Office, ——— —, ——.

Value, $1,883,360.
Exports of domestic commodities, value, $16,372,708.
Exports of foreign commodities, value, $66,164.
Total amount of duties collected, $902,873.90.

STATEMENT OF VESSELS ENTERED AND CLEARED AT THE PORT OF GALVESTON, TEX., DURING THE YEAR ENDED JUNE 30, 1881.

CUSTOM-HOUSE, GALVESTON, TEX.,
Collector's Office, ——— —, ——.

ENTRANCES.

American:	
Number	369
Tons	339,141

Foreign:	
Number	235
Tons	191,197
Total:	
Number	604
Tons	530,338

CLEARANCES.

American:	
Number	404
Tons	368,016
Foreign:	
Number	207
Tons	150,680
Total:	
Number	611
Tons	518,696

O 4.

IMPROVEMENT OF SHIP CHANNEL IN GALVESTON BAY, TEXAS.

Survey of Buffalo Bayou for a channel of navigation through Buffalo Bayou and Galveston Bay to Bolivar Channel was made in 1870–'71. (See Report of the Chief of Engineers, 1871, pp. 533–537.)

Survey "for ship channel through Galveston Bay, from 12 feet water in the mouth of San Jacinto River * * * to 12 feet water in Galveston Channel," was made in 1876–'77. (See Report of Chief of Engineers, 1876, pp. 455–468.)

Appropriation of June 10, 1872, $10,000, was for improvement of bar in Galveston Bay, and together with the appropriation of June 23, 1874, $10,000, for the improvement of Red Fish Bar, was applied to the dredging of a channel through Red Fish Bar, 1,500 feet long, 70 feet wide, and over 7 feet deep.

Appropriations of 1875 were: improvement of Red Fish Bar, $10,200; improvement of ship channel between mouth of San Jacinto River to Bolivar Channel, $25,000, by which a channel was made (between Bolivar Channel and mouth of San Jacinto River, and through Red Fish Bar) 6,100 feet in length, 14½ feet in depth, connecting depths in channel of 9 feet, and 8½ feet in the upper and lower bays, and with the private work of improvement at Morgan's Point, permitting the passage of vessels of 9 feet draught to within a short distance of Houston.

Appropriation of 1876, $72,000, and appropriation of 1878, $75,000, were made applicable to that portion of the channel between Red Fish Bar and Bolivar Channel, and were so applied; the channel dredged being 12 feet deep, and 100 feet wide at bottom.

Appropriation of 1879, $80,000, was made "applicable on a direct line between the cut through Morgan's Point, subject to conditions * * * required by the United States, before application of the money appropriated."

Appropriation of 1880, $50,000, was for improving ship channel in Galveston Bay, continuing improvement.

Appropriation of 1881, $50,000, is for improving ship channel in Galveston Bay.

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1881.

On the 16th of August, 1880, a project for the expenditure of the funds of the appropriations of 1879 and 1880, amounting to $130,000, and the balance of appropriation of 1878, $25,000, was forwarded.

The action taken upon this project was as follows:

LETTER FROM THE OFFICE OF THE CHIEF OF ENGINEERS, AUGUST 26.

[Extract.]

And the records of this office do not show that the terms of the act of Congress, March 3, 1879, have been complied with, as required of Secretary of War in letter dated September 26, 1879, in order that the work may be commenced under the appropriation for ship channel in Galveston Bay, in the above-named act.

* * * * * * *

By means of this, all action looking towards improvement of the channel was deferred until March, 1881, when notification was received (letter of February 28, office of the Chief of Engineers) that the individual members and stockholders of the Buffalo Bayou Ship Channel Company had, January 2, 1881, accepted the conditions imposed by the terms of the act of March 3, 1879, the preamble and resolution adopted by the individuals composing the company having been first approved of, "as satisfactory to the department." Letter of February 25, 1881, War Department, Washington City. (See copy of papers hereto appended.)

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Project for the expenditure of the funds of appropriations of 1879 and 1880, viz, $130,000, was submitted March 8, 1881.

The work to be done to consist in dredging a channel 100 feet wide, from the upper end of the government cut at Red Fish Bar, through Red Fish Bar, and then up to Morgan's Cut, a distance of about 7½ miles through Galveston Bay; and a further extension (if funds permit) in widening and deepening Morgan's Cut.

The uniform depth of water to be obtained is 12 feet at mean low-tide, the average depth of water along the proposed line at present being 8½ feet, varying from 7 to 10 feet.

The following is an abstract of bids received in response to an advertisement bearing date April 7, 1881:

Abstract of proposals for dredging in Galveston Bay, Tex., in response to advertisement dated April 7, 1881, and opened May 9, 1881, by Maj. S. M. Mansfield, Corps of Engineers.

No.	Names of bidders.	Material excavated and removed.	Remarks.
		Per cub. yd.	
1	Jos. E. Slaughter	$0 13.7	
2	George C. Fobes & Co	17¾	
3	G. L. Long	15.4	Informal; not in duplicate.
4	John J. Atkinson	24	

The lowest bidder was Joseph E. Slaughter, of Cedar Keys, Fla., to whom was awarded the contract of dredging the channel required, 890,000 cubic yards, at 13.7 cents per yard; the articles of agreement, dated July 17, 1881, fixing the date of commencement of work September 5, 1881, and of its completion, September 5, 1882.

Original estimates (for channel 100 feet wide and 12 feet deep), 1877	$446,326 42
Appropriated 1872 to 1881	352,000 00
Unappropriated balance of estimate of 1877	94,326 42

Which sum (together with the last appropriation of $50,000) can be profitably expended in the fiscal year ending June 30, 1883, in continuing operations for improvement as originally estimated for.

The reports heretofore submitted carry the impression that this work cannot be considered as one of a permanent character.

The work is in the collection district of Galveston. The light-houses on or near the line of the work are (1*) near Clopper's Bar, at the mouth of the San Jacinto River; (2) in Red Fish Bar; and (3) at Bolivar Point.

For commercial statistics see report on improvement of Galveston Harbor and Entrance; also report on Buffalo Bayou improvement.

This work is designed to accommodate a large portion of the commerce of the district.

Money statement.

July 1, 1880, amount available	$155,313 61	
Amount appropriated by act approved March 3, 1881	50,000 00	
		$205,313 61
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		1,834 87
July 1, 1881, amount available		203,478 74
Amount (estimated) required for completion of existing project		94,326 42
Amount that can be profitably expended in fiscal year ending June 30, 1883		94,326 42

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 26, 1880.

SIR: Referring to your letter of August 16, inclosing project for improvement of ship channel in Galveston Bay, there are inclosed for your information copies of the following papers:

I. Letter from Judge-Advocate-General, dated September 17, 1879.
II. Letter from Secretary of War, dated September 26, 1879.
III. Letter from A. S. Richardson, secretary Buffalo Bayou Ship Channel Company, dated October 27, 1879.

The last-named paper is the latest communication from Mr. Richardson, and the records of this office do not show that the terms of the act of March 3, 1879, have been complied with as required of Secretary of War, in letter dated September 26, 1879, in order that the work may be commenced under the appropriation for ship channel in Galveston Bay, in the above-named act.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Acting Chief of Engineers.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

LETTER OF JUDGE-ADVOCATE-GENERAL.

WAR DEPARTMENT,
BUREAU OF MILITARY JUSTICE,
September 17, 1879.

Respectfully returned to the Secretary of War, through the Chief of Engineers, calling attention to the 3d indorsement on this paper, being

* Discontinued April 1, 1880.

the indorsement of this bureau dated August 9, 1879, in which it is stated:

> There must still be, in order fully to effectuate this enactment, a formal conveyance and surrender by the company (Buffalo Bayou Ship Channel Company) to the United States of their work at Morgan's Point, and their charter, granted by the legislature of Texas, and their rights accruing thereunder.

The proposition from the company, on which the action of Congress was based, is as follows:

> Whereas it is the desire of this company to facilitate the construction of a 12-foot ship-channel through Galveston Bay by the Government of the United States: Therefore,
>
> *Resolved*, That when the Government of the United States shall have completed a ship channel for vessels of 12 feet draught from Bolivar Channel to the channel constructed by this company, it will turn over and surrender to the United States Government the said work at cost, or at the valuation that may be placed upon it by a commission of United States Engineers, designated by the Government of the United States, to determine the value of the same.

But Congress did not accept the proposition as made. The act (page 367, Statutes, 1878–'79) states that—

> In consideration of the proposition of the Buffalo Bayou Ship Channel Company to turn over their work at Morgan's Point, *and to surrender their charter, granted by the legislature of Texas, and the rights accruing thereunder, to the United States*, which proposition is now on file in the War Department, and is hereby accepted, &c.

Passing by the fact that the description of "the work" in the proposition and the act are not identical, attention is called to the fact that the company made no proposition "to surrender their charter, granted by the legislature of Texas, and the rights accruing thereunder, to the United States," and no such proposition has ever been on file in the War Department.

The act of Congress proceeds to make an appropriation of $80,000, "for the improvement of that line," with this proviso—

> That no part of said sum shall be expended until said Buffalo Bayou Ship Channel Company shall file with the Secretary of War, in manner and form to be by him approved, their acceptance of this provision of this act.

This proviso must mean that the company is required, as a preliminary to the expenditure of any part of said appropriation, to file with the Secretary of War their acceptance of the terms of this act.

The company has filed with the Secretary of War a paper which it is supposed was expected to be received by him as compliance with the requirements of the act. This paper recites that—

> Whereas the proposal made by this company to the Government of the United States on the 12th day of January, 1878, and filed with Hon. G. W. McCrary, Secretary of War, has been accepted by the Government of the United States, in the act making appropriation for the construction, repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes, approved March 3, 1879: Therefore,
>
> *Resolved*, That the provisions of the act making appropriations for the construction, repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes, approved March 3, 1879, accepting the proposal of this company made January 12, 1878, to-wit (and then inserts the original proposition given above, which was and is now on file in the War Department), is hereby accepted by this company, and *the terms of the said proposal are hereby reiterated and reaffirmed.*

It will thus be observed that the company does not accept the provisions of the act of Congress making conditions not in the proposition of the company, and, that there may be no mistake as to this point, declares in effect that the company accepts the act of Congress only in

so far as it accords with the original proposition of the company, declining to comply with the further requirements made by Congress.

It is my opinion that no part of said appropriation can legally be expended until Buffalo Bayou Ship Channel Company shall turn over their work at Morgan's Point and surrender their charter granted by the legislature of Texas, and the rights accruing thereunder, to the United States.

In order to accomplish this, there should be adopted by the board of directors of the company a resolution (reciting the act of Congress and the expenditure proposed to be made thereunder, and the payments to be made, as in the proposition of the company, as the consideration) conveying to the United States the company's work at Morgan's Point, and transferring and surrendering to the United States their charter granted by the legislature of Texas, and the rights accruing thereunder, and authorizing the proper officer, or officers, under the seal of the company, to make the proper transfer and conveyance.

On the execution and delivery of a conveyance in pursuance of said resolution, and on the transfer by each stockholder of all his shares in the stock of said company to the United States, the above appropriation may be legally expended.

I think it necessary that each stockholder should surrender and transfer his stock to the United States, because, while the directors of the company are authorized by the charter to sell and alienate the property of the company, they have no authority to dispose of its charter.

W. M. DUNN,
Judge-Advocate-General.

LETTER OF THE SECRETARY OF WAR TO THE SECRETARY OF THE BUFFALO BAYOU SHIP CHANNEL COMPANY.

WAR DEPARTMENT,
Washington City, September 26, 1879.

SIR: Referring to your letter of July 16 last, inclosing copy of preamble and resolution adopted by the stockholders of the Buffalo Bayou Ship Channel Company, July 14, 1879, accepting the provisions of so much of the river and harbor act of March 3, 1879, as relates to the construction of a 12-foot ship channel through Galveston Bay, I have respectfully to state, in reply, that it is observed that the company, in the document transmitted, does not accept the provisions of said act of Congress making conditions not in the original proposition of the company, and inviting your attention to inclosed copy of the opinion of the Judge-Advocate-General in the case which is concurred in by me. I beg to inform you that, before any payment under the act referred to can be made to the company, it is necessary that all the conditions mentioned in the said opinion be fully complied with.

Very respectfully,

GEO. W. MCCRARY,
Secretary of War.

A. S. RICHARDSON, Esq.,
Secretary Buffalo Bayou Ship Channel Company, Houston, Tex.

LETTER OF THE SECRETARY BUFFALO BAYOU SHIP CHANNEL COMPANY TO THE SECRETARY OF WAR.

OFFICE OF BUFFALO BAYOU SHIP CHANNEL COMPANY,
Houston, Tex., October 27, 1879.

SIR: Your favor of 26th of September ultimo, relative to the action of the Buffalo Bayou Ship Channel Company accepting the provisions of so much of the river and harbor act of March 3, 1879, as relates to the construction of a 12-foot ship channel through Galveston Bay, has been received.

The points raised by you are such as will require the action of the stockholders of said company, in order to comply with the conditions suggested by you, and not contained in the original proposition of said company.

When such further action has been taken due notice thereof will be forwarded.

I am, very respectfully, &c.,

A. S. RICHARDSON,
Secretary Buffalo Bayou Ship Channel Company.

Hon. GEO. W. MCCRARY,
Secretary of War.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 28, 1881.

SIR: The inclosed copy of the acceptance by the individual members and stockholders of the Buffalo Bayou Ship Channel Company of the provisions of the river and harbor act of March 3, 1879, containing an appropriation of $80,000 for the improvement of the "line surveyed from the cut in Red Fish Bar to the cut in Morgan's Point," with the condition "that no part of said sum shall be expended until said Buffalo Bayou Ship Channel Company shall file with the Secretary of War, in manner and form to be by him approved, their acceptance of this provision of this act," with the indorsement of the Chief of Engineers, the Judge-Advocate-General of the Army, and the instructions of the Secretary of War to the Chief of Engineers thereon, is transmitted for your information and guidance.

A copy of the letter of the honorable the Secretary of War, to the Hon. R. Q. Mills, dated February 29, 1881, stating "that the said instrument is satisfactory to the department," is also inclosed for your information.

You will please, accordingly, give the subject your early attention, and submit to this office a project for the application of the available funds, stating the amount of the same.

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Lieutenant-Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Major S. M. MANSFIELD,
Corps of Engineers, U. S. A.

PREAMBLE AND RESOLUTIONS OF BUFFALO BAYOU SHIP CHANNEL COMPANY, ACCEPTING THE PROVISIONS OF THE RIVER AND HARBOR ACT OF MARCH 3, 1879.

Whereas, by an act of Congress approved March 3, 1879, the sum of $80,000 was appropriated for the improvement of the line surveyed from the cut in the Red Fish Bar to the cut in Morgan's Point, in Galveston Bay, in the State of Texas, upon the proviso and condition as contained in said act, to-wit:

In consideration of the proposition of the Buffalo Bayou Ship Channel Company to turn over their work at Morgan's Point and to surrender their charter, granted by the legislature of Texas, and the rights accruing thereunder, to the United States, which proposition is now on file in the War Department, and is hereby accepted, the government adopts the line surveyed from the cut in Red Fish Bar to the cut in Morgan's Point, and the sum of $80,000 is hereby appropr ated for the improvement of that line: *Provided*, That no part of said sum shall be expended until said Buffalo Bayou Ship Channel Company shall file with the Secretary of War, in manner and form to be by him approved, their acceptance of the provision of this act.

Now, therefore, we, the undersigned, being all the individual members and stockholders of said company, do hereby formally accept the said provision of said act, and do further, in consideration of said appropriation, covenant and agree, that upon the completion of the said improvement, we will enter into and subscribe any and all such instrument, or instruments, as may be necessary, or required, in order fully to transfer and surrender to the United States the entire said work, together with the charter and rights aforesaid.

Witness our hands and seals, this 22d day of January, A. D. 1881.

THE MORGAN LOUISIANA AND TEXAS
RAILROAD AND STEAMSHIP COMPANY,
By CHAS. A. WHITNEY, *President*.

[SEAL.] JNO. B. RICHARDSON, *Secretary*.

E. W. CAVE.	[SEAL.]
A. S. RICHARDSON.	[SEAL.]
JOHN SHEARER.	[SEAL.]
T. W. HOUSE.	[SEAL.]
J. R. MORRIS.	[SEAL.]
T. H. ZEANLAN.	[SEAL.]
A. GROSBRECK.	[SEAL.]
WIGGINS & SIMPSON.	[SEAL.]
CHAS. FOWLER.	[SEAL.]
W. B. BOLTS.	[SEAL.]
CHAS. A. WILNEY.	[SEAL.]
A. S. HUTCHINSON.	[SEAL.]

I hereby certify that the names appended to the instrument of writing hereto attached comprise all the stockholders of the Buffalo Bayou Ship Channel Company, owning paid up stock in said company, and also the names of all those entitled to receive stock upon the payment of the balance due upon their subscription to stock, except the name of one subscriber for twenty shares, of $100 each, and upon which subscription there has been paid in but one installment of five per cent. ($100).

I further certify that a copy of said instrument of writing has been filed in the book of transfer of stock of said company.

Witness my signature as secretary of said company, with the seal thereof affixed, at the company's office in the city of Houston, this February 14, 1881.

[SEAL.] A. S. RICHARDSON,
Secretary.

[First indorsement.]

WAR DEPARTMENT,
February 21, 1881.

Respectfully referred to the Chief of Engineers for report.
By order of the Secretary of War.

JOHN TWEEDALE,
Acting Chief Clerk.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS, U. S. ARMY,
February 21, 1881.

Respectfully returned to the Hon. the Secretary of War.

On the 16th of July, 1879, Mr. A. S. Richardson, secretary of the Buffalo Bayou Ship Channel Company, submitted a copy of a preamble and resolution adopted by the company, accepting the provision of the river and harbor act of March 3, 1879, relative to the construction of a 12-foot ship channel through Galveston Bay. This acceptance is required to be made in such manner and form as to meet the approval of the Secretary of War, and was accordingly sent to the Judge-Advocate-General of the Army, who after full consideration of the whole question gave the opinion that the Buffalo Bayou Ship Channel Company—

Does not accept the provision of the act of Congress making conditions not in the proposition of the company, and that there may be no mistake as to this point, declares in effect that the company accepts the act of Congress only in so far as it accords with the original proposition of the company, declining to comply with the further requirements made by Congress.

It is my opinion that no part of said appropriation can legally be expended until the Buffalo Bayou Ship Channel Company shall turn over their work at Morgan's Point, and surrender their charters granted by the legislature of Texas, and the rights accruing thereunder, to the United States.

* * * * * * *

Under date September 26, 1879, the Secretary of War transmitted a copy of this opinion to the secretary of the Buffalo Bayou Ship Channel Company, in which it was stated that—

Before any payment under the act referred to can be made to the company, it is necessary that all the conditions mentioned in the said opinion be fully complied with.

In reply to the above letter of the honorable the Secretary of War, the secretary of the company under date October 27, 1879, stated that—

The points raised by you are such as will require the action of the stockholders of said company in order to comply with the conditions suggested by you, and not contained in the original proposition of said company.

When such further action has been taken due notice thereof will be forwarded.

The matter has remained in *statu quo* until the reception of the within papers, which are designed to meet the requirements of the Judge-Advocate-General, and which it is suggested should be referred to him for opinion.

Previous papers herewith.

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

[Third indorsement.]

Respectfully referred to the Judge-Advocate-General for opinion.
By order of the Secretary of War.

JOHN TWEEDALE,
Acting Chief Clerk.

WAR DEPARTMENT,
February 23, 1881.

[Fourth indorsement.]

BUREAU OF MILITARY JUSTICE,
February 23, 1881.

Respectfully returned to the Secretary of War.

The within instrument of acceptance and agreement, purporting to be signed by all the members and stockholders of the company named, is in accordance with the last opinion relating to such company, contained in the communication of the Judge-Advocate-General of January 15, 1880, addressed to Hon. S. B. Maxey, United States Senator, a copy of which is inclosed, as also in accordance with a *form* prepared for the purpose by this bureau, and furnished to the Hon. R. Q. Mills, member of Congress of Texas, and by him procured to be executed by the signers.

Supposing of course the signers to be, in fact, "all the individual members and stockholders" of the company, I have to report that the within instrument is, in my opinion, a full a sufficient "acceptance," within the requirements of the provision (therein recited) of the act of March 3, 1879, and that the appropriation for the improvement there specified may now legally be commenced to be expended, pursuant to said provision.

W. WINTHROP,
Acting Judge-Advocate-General.

LETTER OF SECRETARY OF WAR TO HON. R. Q. MILLS, HOUSE OF REPRESENTATIVES.

WAR DEPARTMENT,
Washington, February 25, 1881.

SIR: I have the honor to acknowledge the receipt of the preamble and resolution adopted by the stockholders of the Buffalo Bayou Ship Channel Company, January 22, 1881, accepting the provisions of so much of the river and harbor act of March 3, 1879, as relates to the construction of a 12-foot ship channel through Galveston Bay, which was left here by you, and in reply I beg to inform you, that said instrument is satisfactory to the department and that accordingly the Chief of Engineers has been instructed to take such further steps as may be necessary to carry out the act of Congress referred to.

Very respectfully, your obedient servant,

ALEX. RAMSEY,
Secretary of War.

Hon. R. Q. MILLS,
House of Representatives.

O 5.

IMPROVEMENT OF TRINITY RIVER, TEXAS.

Survey of the mouth of Trinity River was made in 1871. (See Report of the Chief of Engineers, 1871, pp. 537–39.)

Survey of the river from its mouth to Magnolia, Tex., was made in 1872–'73. (See Report of the Chief of Engineers, 1873, pp. 685–91.)

Re-survey of the river from its mouth to the bridge of the Great

Northern Railroad was made in 1879. (See Report of the Chief of Engineers, 1880, pp. 1239–1242.)

Appropriation of 1878, $10,000, was for deepening channel at the mouth of the river, and removing obstructions to Liberty, and was applied to dredging a channel across the bar at the mouth of the river.

Appropriation of 1879, $2,500, was for "improving mouth of Trinity River," and was applied to deepening and widening the channel across the bar at the mouth.

Appropriation of 1880, $4,000, was for improving Trinity River, continuing operations, and is to be applied in cutting channel through the bar 4½ miles below Liberty, and in removing snags between Liberty and the mouth, and in conjunction with the—

Appropriation of 1881, $10,000, which was for improving Trinity River.

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1881.

The work of dredging on the bar at the mouth of the river (mentioned as incomplete in last year's report), under the contracts of June 10 and November 14, 1879, with Mr. Seth N. Kimball, was completed by the close of July, final payment being made August 4, 1880.

The work accomplished under the terms of the two contracts above mentioned covered the removal of 47,300 cubic yards of material from the bar, leaving a dredged channel of not less than 5½ feet depth, averaging 110 feet width, and in length across the bar 4,800 feet.

From August 1, 1880, and until the close of the fiscal year, June 30, 1881, active operations were suspended, for the reason that it was thought that the small amount of available funds would not attract the attention of responsible bidders.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

A project was rendered on the 30th of March, 1881, in which was proposed the expenditure of so much of the available funds of the appropriation of 1880–'81, in cutting out the sand-bar and removing snags between Liberty and the mouth of the river, as may be necessary; to be done by contract.

An advertisement bearing date May 14, 1881, invited proposals for the improvement mentioned.

The following is an abstract of bids received in response to the advertisement:

Abstract of proposals for improving the Trinity River, Texas, in response to advertisement, dated May 14, 1881, *and opened June* 13, 1881, *by Maj. S. M. Mansfield, Corps of Engineers.*

No.	Bidder.	Improving navigation of the river.
1	G. L. Long	At a total of $7,500.

The proposal of Mr. G. L. Long was accepted, and contract will be entered into with him in due season, in accordance with his proposal and in conformity with the specifications governing the work to be done.

ORIGINAL ESTIMATES.

Work at the mouth, dredging and pile breakwater (1871)	$40,000 00
Work at the mouth, dredging and removing snags between Liberty and the mouth (1873)	22,581 40
Dredging bar and removing snags below Liberty, and dredging on the bar at the mouth of Middle Pass (1880)	*36,541 00

Twenty-six thousand five hundred and forty-one dollars might be expended in the fiscal year ending June 30, 1883, in continuing operations—dredging, removing snags, &c., as may be necessary.

There is no basis for estimates as to the length of time the cuts made through the bar at the mouth and the bar near Liberty will remain open for navigation, or, as to the cost of maintaining the river from its mouth to Liberty in a navigable condition.

The work is located in the collection district of Galveston; nearest light-house, Red Fish Bar, Galveston Bay.

Money statement.

July 1, 1880, amount available	$10,304 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$20,304 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,734 44
July 1, 1881, amount available		14,569 56
Amount that can be profitably expended in fiscal year ending June 30, 1883.		26,541 00

OMMERCIAL STATISTICS—LETTER FROM HY. WILSON, STEAMER VICKSBURG.

Steamboats running on the river, four, with ordinary draught of 5 feet; schooners and wood boats, &c., aggregate tonnage, 500 tons. Bales of cotton, which seek the river, as the natural and cheapest transportation, 2,500; logs of cypress, pine, &c., cut in the vicinity of the river, 1,000,000 feet, B. M.; lumber shipped, 500,000 feet, B. M.; a small quantity of cedar telegraph poles, say 1,000 per annum.

About one-third of the fire-wood consumed by Galveston comes out of the lower part of the river. Various—staves, cane, and brush for government work, cotton seed.

There is no saw-mill on the river below Bremond N. G. Railroad bridge.

If for about 20 miles above Liberty the river were cleared of snags, and 4 feet of water made on Green's Bar, about 7 miles above Liberty, the best body of timber on the river would be open to manufacture, and any quantity of cane for government work would be obtainable all the year.

O 6.

IMPROVEMENT OF BUFFALO BAYOU, TEXAS.

Survey of Buffalo Bayou, from the mouth to Houston, was made in 1870–'71. (See Report of Chief of Engineers, 1871, pp. 533–536.)

Examination of Buffalo Bayou, Texas, from Simm's Bayou to the mouth of White Oak Bayou, at Houston, was made in 1880; report on same being contained in House Ex. Doc., No. 53, Forty-sixth Congress, third session, copy herewith.

Appropriation of March 3, 1881, $25,000, is the first appropriation for this improvement, and is made applicable "to secure a channel of 100 feet."

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* This sum is given for the first time; not mentioned in last report.

PROPOSED OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Project for the expenditure of the $25,000 appropriated was forwarded April 25, 1881; and in accordance with that project, an advertisement bearing date June 7, 1881, invites proposals for the improvement of the bayou; the bids to be opened July 6, 1881.

The work to be done is designed to improve (to the limited extent of the appropriation) the navigation of the bayou, by removing overhanging trees, and by dredging the shoalest places in the bayou, just below Houston. The estimated amount of dredging, 75,000 cubic yards; estimated number of overhanging trees to the mile, 700.

If satisfactory bids are received in response to the advertisement mentioned, contract will be entered into with the lowest responsible bidder; work to commence within ninety days after notification of approval of contract, and to be prosecuted with all due diligence to completion.

ESTIMATES.

For a channel 12 feet deep and 100 feet wide:	
Excavating 1,313,130 cubic yards, at 25 cents	$328,282 50
7,900 linear feet sheet piling, at $2.50	19,750 00
Removing overhanging trees, 11.2 miles, at $200	2,240 00
	350,272 50
Add 10 per cent. for contingencies	35,027 25
Total cost	385,299 75
For a channel 12 feet deep and 150 feet wide:	
Excavating 4,004,190 cubic yards, at 25 cents	$1,001,047 50
7,900 linear feet sheet piling, at $2.50	19,750 00
Removing overhanging trees, 11.2 miles, at $200	2,240 00
	1,023,037 50
Add 10 per cent. for contingencies	102,303 75
Total cost	1,125,341 25
The total estimated for 100-foot channel, 12 feet deep	385,299 75
The amount appropriated	25,000 00
Unappropriated balance	360,299 75

Of which amount $100,000 can be profitably expended, in making the improved navigable channel desired, during the fiscal year ending June 30, 1883.

It is in the collection district of Galveston, and the nearest light-houses are those at Clopper's Bar, Red Fish Bar, and at Bolivar Point.

For commercial statistics, see reports on Galveston Harbor and Entrance, ship channel in Galveston Bay, and report of examination, herewith.

Money statement.

Amount appropriated by act approved March 3, 1881	$25,000 00
July 1, 1881, amount available	25,000 00
Amount (estimated) required for completion of existing project	360,290 75
Amount that can be profitably expended in fiscal year ending June 30, 1883	100,000 00

EXAMINATION OF BUFFALO BAYOU, TEXAS, FROM SIMM'S BAYOU TO THE MOUTH OF WHITE OAK BAYOU AT HOUSTON.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., January 10, 1880.

GENERAL: I have the honor to transmit herewith a report of the examination of Buffalo Bayou, Texas, from Simm's Bayou to the mouth of White Oak Bayou at Houston, made in accordance with the provisions of section 2 of act of Congress approved June 14, 1880.

The examination was made by Assistant Engineer Mr. R. B. Talfor, and his report, entire, is submitted herewith, with map and cross-sections.

A survey of this bayou was made by Lieut. (now Captain) H. M. Adams, Corps of Engineers, under Major Howell's direction, in December, 1870, and January, 1871, report of which may be found on page 534, Report of Chief of Engineers for 1871.

Mr. Talfor was directed to cross-section the bayou at nearly the same places as had been done by Lieutenant Adams, with a view to a comparison and determination of changes. We have been unable to determine Lieutenant Adams's plane of reference; we show, however, that some important changes have occurred, and can approximate very nearly to the exact amount.

For 3 or 4 miles below the city of Houston the banks range from 20 to 45 feet in height, and at some points are very bluff, with a tendency to caving during high-water.

The narrowness and tortuousness of the bayou for this distance, with its sharp bends, are the most serious obstructions to its navigation.

For a channel 12 feet deep and 100 feet wide the following estimate is submitted:

Excavation, 1,313,130 cubic yards, at 25 cents	$328,282 50
Sheet piling, 7,900 feet, at $2.50	19,750 00
Removing overhanging trees	2,240 00
Contingencies, 10 per cent	35,027 25
Total	385,299 75

For a channel 12 feet deep and 150 feet wide:

Excavation, 4,004,190 cubic yards, at 25 cents	$1,001,047 50
Sheet piling, 7,900 feet, at $2.50	19,750 00
Removing overhanging trees	2,240 00
	1,023,037 50
Contingencies, 10 per cent	102,303 75
Total	1,125,341 25

* * * * * * *

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Colonel, U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. R. B. TALFOR, ASSISTANT ENGINEER.

GALVESTON, TEX., *December* 24, 1880.

SIR: I have the honor to submit the following report of an examination of Buffalo Bayou, Texas, from Simm's Bayou to the mouth of White Oak Bayou at Houston.

* * * * * * *

Buffalo Bayou, above its junction with White Oak Bayou at Houston, is innavigable, the width and depth being reduced to the minimum (see chart), but below this point it is navigable for boats drawing from 5 to 6 feet of water. For 3 or 4 miles below the city of Houston the banks range from 20 to 45 feet in height, and at some points are very bluff, with a tendency to caving during high-water. The narrowness and tortuousness of the bayou for this distance, with its sharp bends, are the most serious obstructions to its navigation.

It is a tide-water stream, emptying into the San Jacinto River at Lynchburg, abont 25 miles below Houston. At Clinton, the present terminus of the Morgan's steamship line, a portion of the banks has been excavated and the channel dredged to enable their large steamers to turn there. (See chart.)

Simm's Bayou debouches into Buffalo Bayou about one-fourth of a mile below. No perceptible current was observed out of it. For a further description of the bayou below Clinton I would respectfully refer to Lieutenant Adams's report of 1871.

* * * * * * *

The banks at Clinton are from 10 to 20 feet high, gradually increasing in height as they recede from the bayou, and are composed of a yellow clay mixed with sand and loam. Very little, if any, caving occurs till within one-half mile below Harrisburg, where the right bank appears to be composed of the same material, but with an excess of sand in the underlying stratum, causing it to undermine during high-water. From Harrisburg to cross-section No. 31 the banks appear to be stable, no indications of caving or sliding being observed. Above this point four land slides have occurred, narrowing the channel; the most notable one is shown at section No. 20, the width of the bayou above and below this point being 123 and 138 feet, respectively.

The chart of 1871 gives the width of section No. 20 as 96 feet; its present width is only 65 feet.

Overhanging trees, consisting of oak, cottonwood, a few pine, and magnolias, line the banks, with but few open spaces from Simm's bayou to within 2 miles of Houston. From there the left bank to Houston is clear, with the exception of that portion embraced between cross-sections No. 8 and No. 12. (See chart.)

At Houston, and for about 5 miles down stream, the banks are composed of a blue and yellow clay with sand mixed, the underlying stratum being of a hard blue clay, and are from 15 to 45 feet high, being quite bluff as you approach Houston. The caving of the banks (excepting the conditions mentioned above) is due in a great measure to their denudation of timber and their cultivation; the heavy rains washing the surface soil, causing great fissures or ravines in the banks. The cause of caving is especially noticeable at section No. 20, where the land slide (as mentioned above) was due to the gullies at its upper and lower extremities and percolation through the layers of sand. The combined effect of these causes is, that large quantities of earth are washed into the bayou during the prevalence of heavy rains and floods. Wherever the bayou shoals above the depth required for the Houston Direct Navigation Company's barges, it is dredged by that company.

A table of comparisons of the sections made in 1870 and 1871, and November, 1880, shows that the average area of section of the bayou has increased in width and depth; from 2 to 43 feet in width, and from $\frac{3}{4}$ of a foot to $5\frac{1}{2}$ feet in depth. Their extremes are shown in the table at sections Nos. 7 and 21 for width, and sections Nos. 6 and 35 for depth. A narrowing of area from 2 to 31 feet is shown at sections Nos. 20 and 34. The 31 feet narrowing being at the land slide already mentioned at section No. 20. A shoaling from 1 to $3\frac{1}{2}$ feet is observed at a few of the sections.

The above comparisons of sections taken would indicate that the plane of reference of 1871 was taken lower than the one established during the time of this survey.

PROPOSED IMPROVEMENT.

For a channel 100 feet wide and 12 feet deep between Houston and Clinton, the amount of material to be excavated is 1,313,130 cubic yards.

That portion of the bayou requiring the greatest amount of dredging is located between Houston and cross-section No. 22 (3 miles below), where the quantity to be taken out is 756,325 cubic yards against 556,805 cubic yards for the remaining 8 miles to be improved.

For a channel 150 feet wide and 12 feet deep, the amounts to be excavated over the same sections as mentioned above are, respectively, 1,685,875 cubic yards for the 3 miles and 2,318,315 cubic yards for the remaining 8 miles.

The upper portion of the bayon near Houston being narrow, with high banks, will necessitate an extra moving of the material dredged for a channel 150 by 12 feet, but for a channel 100 by 12 feet one movement will be obtained by the use of a steam derrick, such as is now used by the Houston Direct Navigation Company, which has a boom 85 feet long with a swing of 75 feet clear from the center of the derrick. As all the excavated material will have to be deposited on the banks, the stumps of the trees

that have been removed will greatly assist in preventing the material from sliding back and holding together the levee thus formed.

Wherever a tendency to caving of the banks is observed, a revetment of sheet piling will be required; that being in use now, and put in by the Houston Direct Navigation Company, at a few points near Houston, the cost of which, with other information, was kindly rendered by Captain J. J. Atkinson, is as follows:

Piling of Calcasieu or Sabine pine 12 inches diameter by 25 feet long, 4-inch by 8-inch stringers, cap 4 inches by 12 inches, sheeting 2 inches by 12 inches. Total cost per running foot, $2.50. The cost of the piling could be greatly reduced, as the overhanging trees to be removed could be utilized for this purpose.

ESTIMATE FOR A 100-FOOT CHANNEL BETWEEN SIMM'S AND WHITE OAK BAYOUS.

Excavating 1,313,130 cubic yards, at 25 cents	$328,282 50
7,900 linear feet sheet piling, at $2.50	19,750 00
Removing overhanging trees, 11.2 miles, at $200	2,240 00
	350,272 50
Add 10 per cent. for contingencies	35,027 25
Total cost	385,299 75

FOR A CHANNEL 150 FEET WIDE AND 12 FEET DEEP.

Excavating 4,004,190 cubic yards at 25 cents	$1,001,047 50
7,990 linear feet sheet piling, at $2.50	19,750 00
Removing overhanging trees 11.2 miles, at $200	2,240 00
	1,023,037 50
Add 10 per cent. for contingencies	102,303 75
Total cost	1,125,341 25

From the above estimates of cost, and from conversations had with a delegation of the merchants of Houston, who called on me while at their city, and the statistics furnished by them and their different corporations, I am led to believe that a channel 100 feet wide and 12 feet deep would answer all the requirements of their trade for some years to come.

The steamships (Morgan's) that are now engaged in the bayou trade, whose present terminus is at Clinton, rarely ever draw more than 9 feet of water. This width will not allow of these steamers passing. An enlargement of cross-section of the bayou at one or two points between Harrisburg and Houston for turnouts would obviate this difficulty.

* * * * * * *

The above estimates are approximate, but I think are within the limit and could be greatly reduced by the engineer in charge of the work of improvement, in taking advantage of those portions of the bayou where the height of one bank is greatly in excess of the opposite one, and making the cut on the lowest bank.

Very respectfully, your obedient servant,

R. B. TALFOR,
United States Assistant Engineer.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

POPULATION, TAXABLE WEALTH, TRADE, COMMERCIAL, INDUSTRIAL, AND OTHER STATISTICS OF THE CITY OF HOUSTON, TEXAS.

The city of Houston has a population of about 20,000. Its situation at the head of tide-water navigation on Buffalo Bayou, only 50 miles from the Gulf of Mexico, gives it command of water transportation, which, although impeded by the shallowness of the bayou approaching Houston, has enabled it to compete for the business and carrying trade of a large portion of the State of Texas. Communication with the Gulf of Mexico and Galveston is had direct, via steamboats, tugs, and barges, and with the present terminus of the ship-channel improvement at Clinton, via the Texas Transportation Railway, 8 miles in length. The following railway lines center at Houston:

	Miles.
Houston and Texas Central Railway, main line	341
Houston and Texas Central Railway, western branch	116
Houston and Texas Central Railway, northwest branch	54

	Miles.
Texas Central Railway	135
International and Great Northern Railway, main line	232
International and Great Northern Railway, Austin division	180
International and Great Northern Railway, Columbia division	50
International and Great Northern Railway, Minneola division	44
International and Great Northern Railway, San Antonio division	80
Galveston, Harrisburg and San Antonio Railway, main line	216
Galveston, Harrisburg and San Antonio Railway, Lagrange division	20
Galveston, Houston and Henderson	50
Texas and New Orleans Railway	105
Gulf, Colorado and Santa Fé Railway	175
Houston, East and West Texas, narrow gauge	75
Texas Western Narrow Gauge Railway	42
Texas Transportation Company	8
Total number of miles	1,923

The assessed valuation of property by latest assessment is $5,452,268. The assessment of Harris County, of which Houston is the county seat, is $9,500,000. The estimated valuation in manufactories of various kinds is $2,083,000.

Estimated sales of merchandise and manufactured goods for year ending September 30, 1880, $13,500,000.

There are two national banks, two incorporation banks, and two private bankers; three cotton compresses; one grain elevator; eleven public school buildings; five private school and academy buildings; and twenty-four churches.

The following is a list of manufacturing and industrial establishments:

Manufactories: Cotton-seed oil, 1; cotton pickeries, 3; wagons and carriages, 8; saddles and harness, 5; sash, doors, &c., 5; paving material, 2; roofing, 1; awnings and tents, 2; patterns and models, 4; saddle-trees, 1; tinware, 9; boilers, 4; brooms, 1; soap, 1; cigars and tobacco, 1; ice, 2; cooperage, 4; copper work, 1; furniture, 7; bone works, 1; patent medicines, 3; candy, 5; wood-turning work, 6.

Other industries: Stone and marble works, 1; boots and shoes, 21; jewelry and watch making, 8; gas-fitting, 2; plumbing, 2; blacksmithing, 12; gunsmithing, 4; bakeries, 15; tailoring, 16; millinery, 6; dressmaking, 6; upholstery, 7; confectioneries, 8; book-binding and printing, 3; newspapers, 6; nurseries, 5; wine (native), 2.

O 7.

IMPROVEMENT OF MOUTH OF BRAZOS RIVER, TEXAS.

Plans and estimates are given in the Report of the Chief of Engineers for 1875, pp. 929–941.

Appropriation of 1880	$40,000
Appropriation of 1881	40,000

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1881.

With the $40,000 appropriated in 1880, a commencement upon the work was made.

An advertisement, bearing date November 10, 1880, invited proposals for building jetty of brush and stone, on concrete, to initiate the work of obtaining a channel of greater depth over the bar than the depth afforded by natural causes.

No bids were received in response to the advertisement, and the following letter will explain the reason why contract for doing the work was entered into with R. Kanters & Son.

GALVESTON, TEX., *December* 13, 1880.

GENERAL: I have the honor to report that no bids were received and entertained for doing the work of improving the mouth of Brazos River, Texas, invited by my advertisement of November 10, 1880.

The firm of R. Kanters & Son (to which firm the contract for Pass Cavallo is about

to be given) was prevented from presenting their proposals until after the noon hour on the day set forth for opening the proposals.

The telegrams (2) herewith are presumptive evidence that the said firm (if not delayed by uncontrollable circumstances) would have put in *bona fide* bids, in fact the same bids which are herewith inclosed (one copy).

I have now to recommend that the proposals of R. Kanters & Son, for the work at Brazos River, be received, and that I be authorized to enter into contract with them in accordance with the terms of their proposals, viz:

	Per cubic yard.
For brush, in mattresses in place	$6 75
For stone in place	8 00
For small stones or gravel in place	6 00
For concrete, in blocks, in place	7 00

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers, Brevet Lieutenant-Colonel, U. S. A.

To the CHIEF OF ENGINEERS, *U. S. A.*

By authority (letter of December 22, 1880, office of the Chief of Engineers) the bid of R. Kanters & Son was accepted, and contract was entered into with them January 19, 1881, for doing the work required, to be completed the 1st of January, 1882.

In February, a survey of the bar and vicinity of the mouth of the river was made, to obtain reliable data wherewith to lay out the lines of the proposed work under the Kanters contract, and the work began immediately thereafter.

At the close of June, 1881, the following was the condition of the work on north channel jetty at this point.

Commencing at the initial point located in-shore (462½ feet from shore-line, limit of high tide), the contractors have built out a line of mattress-work, measuring 742½ running feet.

The work begins with a width of 27.8 feet and gradually widens to 60 feet, with a general thickness (depth of brush mattresses) throughout the line of 3 feet.

The work thus far has been built in place in a trench prepared for it; the sides of the trench having a depth of 2½ feet, the crown in the center having a 3½-foot rise.

The greater portion of this shore work is simply ballasted by a heavy covering of beech sand, which is thought to be sufficient, at least for the present, to serve all practical purposes in protecting the mattress work. For the rest the ballast used is of concrete in blocks, stone not being readily (or cheaply) obtainable.

Thus far the work constructed, owing to its limited extent, has not had any appreciable effect further than to cause a gradual scour along the north channel bank, extending up the river a few hundred feet, from the salient angle of north shore-line of February, 1881.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Messrs. R. Kanters & Son will continue the work of their contract by extending the foundation course of the north jetty—limited by the available funds.

The funds of the appropriation of 1880 are expected to be entirely exhausted by the close of August, when the contract of January 9, 1881, will be closed.

Forty thousand dollars was appropriated by act of March 3, 1881, and the project for the expenditure of this sum was rendered June 6, 1881.

The work will consist in extending the foundation course of the north jetty, and in raising the jetty to a higher level (if necessary) by adding

above the lower course one or more layers of mattresses, overlaid with stone or concrete, and in placing stone or concrete alone upon the work previously laid.

An advertisement bearing date June 20, 1881, invites proposals for this work, the bids to be opened July 20, 1881. Articles of agreement will be entered into with the party offering the most satisfactory bids; the work to commence in September (if possible), and to be completed at the earliest possible date thereafter.

RECOMMENDATIONS AND ESTIMATES.

PROJECT FOR THE IMPROVEMENT OF THE MOUTH OF THE BRAZOS RIVER, TEXAS.

Amount of the appropriation of 1880, $40,000.

The absence of a delta would indicate this to be a non-sediment bearing stream. There are indications of slight deposits of sediment in the bends of the river but none near its mouth. If material in suspension is carried into the Gulf it is immediately swept away by the littoral currents.

In the sharp angle where the Galveston Canal joins the river is a low point of land which is overflowed in time of high-water, but no sediment lodges here, for in time of low-water it is covered with clean grass.

At low river and high tide the water 14 miles up stream is lower than at the mouth.

At low river there is no current. It is like a series of pools up river, separated by sand-bars often dry. Sudden rises occur, and advantage may be taken of these to concentrate the discharge between jetties upon a limited extent of the bar to scour out a channel.

We have no tidal reservoir here, and therefore cannot bring the tide to aid us in any plan of improvement. The tide merely flows over the bar, back and forth, with no power to scour or to maintain a channel.

The river preserves a very uniform width between bold banks, and flows in easy curves; reaches of very deep water are found along the concave bends.

The mouth of the river where most contracted shows a depth of about 10 feet, and this fact, I think, indicates the limit of depth to be maintained by natural causes over the bar after jetties are constructed. For by jetties, we merely propose to transfer the mouth of the river to the position now occupied by the bar, and trust to the littoral currents to delay the reformation of the bar for an indefinite length of time. A greater depth of entrance must, I think, be secured and maintained, if at all, by constant dredging.

Captain Davis submits an estimate for the expenditure of $40,000, available for this work.

We can build about 1,200 feet of jetty; and it is proposed to build the north jetty first, and to put the work out at contract, if a satisfactory contract can be made, after advertising for proposals in the usual manner.

Respectfully submitted.

S. M. MANSFIELD,
Major of Engineers, Brevet Lieutenant-Colonel, U. S. A.

UNITED STATES ENGINEER OFFICE,
Galveston, Texas, August 16, 1880.

The report of the Board of Engineers, to whom this project was submitted, dated September 24, 1880, gives the following estimates:

North jetty, 3,600 feet long, 60,025 cubic yards, at $4.69	$281,517 25
South jetty, 4,350 feet long, 41,330 cubic yards, at $4.69	193,837 70
Contingencies, 10 per cent	47,535 49
Total	522,890 44

(See report of the Board appended hereto.)

The amount appropriated to date is $80,000, leaving still to be appropriated $442,890,40; of which sum $100,000 could be profitably expended in the fiscal year ending June 30, 1883, in continuing operations, viz, building the jetties designed.

The work may not be susceptible of permanent completion, and estimates will vary accordingly.

It is located in the collection district of Galveston, and the nearest light-house is at entrance to Galveston Harbor.

Money statement.

July 1, 1880, amount available	$40,000 00	
Amount appropriated by act approved March 3, 1881	40,000 00	
		$80,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	16,205 26	
July 1, 1881, outstanding liabilities	20,794 74	
		37,000 00
July 1, 1881, amount available		43,000 00
Amount (estimated) required for completion of existing project		442,890 40
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

COMMERCIAL STATISTICS.

CUSTOM HOUSE, *Velasco, Tex., July* 12, 1881.

DEAR SIR: Owing to the absence of J. T. Bissel, my predecessor at this port, there has been no record of the entrance and clearance of vessels kept at this port for the month of July, and up to the 19th of August, 1880, at which time I took charge of this port.

From August 19, 1880, up to June 30, 1881, eighty-two registered vessels have entered and cleared at this port, the aggregate tonnage of which is 1,724.03.

Very respectfully,

WM. E. PARKER.

Mr. J. C. WRIGHT.

STATEMENT OF MR. J. C. WRIGHT, INSPECTOR.

The deepest draught of any vessel that has come in over the bar during the fiscal year ending June 30, 1881, is 5 feet 2 inches, although any vessel can come over the bar drawing between 6 and 7 feet.

Very respectfully, your obedient servant,

J. C. WRIGHT,
United States Inspector.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

STATISTICS OF SUGAR, SIRUP, MOLASSES, AND COTTON MADE IN BRAZORIA COUNTY.

[Furnished through the kindness of Mr. Oscar Nation, editor Independent, Brazoria.]

This county produced last year (1880) about 4,000 hogsheads of sugar and about 9,000 barrels of molasses. This sugar was worth in the market about $75 per hogshead, or a total of about $300,000, and 8,500 barrels of molasses, worth about $15 per barrel, or a total for molasses of about $117,500, making a grand total of about $417,500 produced in this county during the last year from sugar cane alone.

We have tried, with all the ingenuity with which we are possessed, to get the cotton statistics of the county, but have made an entire failure. But it is fair to presume that there was half as much in value as that of sugar. If this is true, our readers can begin to realize something about the vast products of this county, only containing about 10,000 souls.

When this county is as thickly settled as Massachusetts, it will contain a greater population than the State of Delaware, and produce at least *fifty* times as much sugar and cotton as now.

It is now admitted that this is the best sugar-growing region in the United States by the best informed sugar men of the county, who have worked in Louisiana as well as here. There is no industry that pays as well as sugar-planting.

SUGAR, ETC., 1880 to 1881.

We have been for some time engaged in gathering statistics of this county in reference to sugar-growing. We have partially succeeded, and here present our readers with the result of our investigations. In all cases the figures are given by the owners and superintendents, and can therefore be relied on as correct.

"Cedar Brake," owned by Dr. Weems, contains 1,500 acres of land, 225 acres in cul-

tivation, 145 in cane, the balance in corn, potatoes, &c. There has been made 100 hogsheads of sugar and 150 barrels of sirup. The improvements on the farm are worth $15,000. The total loss of sugar on the place is about 60 hogsheads, and 150 barrels molasses.

"Riverside," also belonging to Dr. Weems, has 900 acres of land, 200 acres in cultivation, 75 acres in cane; made 80 hogsheads of sugar, 150 barrels molasses; loss small this year. The improvements are valued at $9,000.

"Willow Glen," owned by G. O. Jarvis, contains 2,000 acres of land, 400 in cultivation, 200 in cane; made 230 hogsheads of sugar, 460 barrels molasses; loss 100 hogsheads sugar and 200 barrels molasses. The improvements are worth $15,000.

"Retrieve," owned by Ball, Hutchings & Co., G. O. Jarvis superintendent, contains 7,000 acres of land, 900 in cultivation, 500 in cane; made 360 hogsheads of sugar, 720 barrels molasses; loss about 150 hogsheads sugar and 300 barrels molasses. Improvements are valued at $20,000.

"Lake Jackson" contains 6,400 acres of land, 600 in cultivation, 300 in cane; made 250 hogsheads of sugar, 500 barrels sirup; lost 200 hogsheads sugar and 400 barrels sirup. The improvements are $25,000.

"Arcola," owned by the House estate, J. H. B. House manager, contains 10,000 acres of land, 2,500 in cultivation, 650 in cane, 275 in cotton; made 450 hogsheads of sugar, 1,500 barrels sirup; lost 400 hogsheads sugar and 800 barrels sirup; made 125 bales cotton. The improvements on this immense plantation are valued at $180,000.

The planters whilst admitting that the cold snap had something to do with their losses, all unite in saying that if they could have had sufficient reliable labor their osses would not have been more than from 5 to 10 per cent. of the whole crop. And, again, to show the immense amount of money this county produces, in this industry alone, these men unite in saying that a well-managed place will make enough outside the sugar to pay all expenses, leaving the sugar clear profit.

TOTAL OF SUGAR, SIRUP, MOLASSES, AND COTTON MADE ON THE ABOVE SIX LARGE PLANTATIONS, INCLUDING ELEVEN SMALLER ONES.

Sugar	hogsheads..	2,800
Sirup	barrels..	4,645
Molasses	do....	1,480
Cotton	bales..	710

The above statistics are valuable, as Brazoria County embraces a large area of country contiguous to the mouth of the river, and would be the part most directly benefited by the improvement of the mouth.

LETTER OF THE CHIEF OF ENGINERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 19, 1880.

SIR: I beg leave to submit herewith a project received August 26, 1880, from Maj. S. M. Mansfield, Corps of Engineers, for the improvement of the mouth of Brazos River, Texas, and for the application of the appropriation of $40,000 made therefor in the river and harbor act of June 14, 1880, and also a report on the subject of this improvement from the Board of Engineers for Fortifications and River and Harbor Improvements, to whom the matter was referred for consideration.

The Board deems it evident that the amelioration, if any, of the channel over the bar at the mouth of this river must come from the use of jetties, and adopts the project of Major Mansfield for the construction with the funds now available of a portion of a jetty on the north side of the entrance, to be composed of alternate layers of mats and stone, leaving its position to be determined by the local engineer upon the general principle that the jetties should be parallel, or nearly so, that they should terminate in 18 or 20 feet water, and that their position be so chosen as to fix the channel in its natural direction.

The probable cost of the whole system is estimated by the Board as follows:

For a north jetty 3,600 feet long	$281,517
For a south jetty 4,350 feet long	193,837
Contingencies	47,535
In all	522,889

This, however, is the approximate limit of cost as it may prove; as the work progresses the shorter jetties will answer the purpose.

Major Mansfield believes that 1,200 feet in length of the north jetty can be built with the present appropriation, the work to be done by contract, if possible.

Concurring in the views of the Board, I beg leave to recommend that the proposed plan of improvement be adopted, and that Major Mansfield be instructed to proceed with the work in accordance with the general rules laid down in the report of the Board, and that his project for the expenditure of the appropriation of June 14, 1880, be approved.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY,
Secretary of War.

[First Indorsement.]

The recommendation of the Chief of Engineers is approved.
By order of Secretary of War.

H. T. CROSBY,
Chief Clerk.

WAR DEPARTMENT, *October* 21, 1880.

REPORT OF THE BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS,
AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, September 24, 1880.

GENERAL: The Board of Engineers, to whom was submitted the project of Maj. S. M. Mansfield, Corps of Engineers, for improving the channel over the bar at the mouth of the Brazos River, Texas, under the appropriation of $40,000 granted during the last session of Congress, have the honor to report:

The Coast Survey Chart of 1858 shows a depth at mean low-water of 8 feet over the bar, distant about 820 yards from the outlet of the river. The survey of 1874 and 1875, made under the direction of Major Howell, gives results not at all so favorable, and it is advisable to quote from the report of Assistant Engineer R. B. Talfor, who personally superintended the survey.

THE BAR.

The depth of water on it is undergoing a continual change, due to the winds and tide and different stages of water on the river. For instance, in October, 1874, only 2½ to 3 feet were to be found.

In April, 1875, and subsequent to the rise in the river, and the effect of a "norther"

at the same time, the bar deepened to 6 feet, but this depth was of short duration, and was reduced to its normal depth of about 3½ feet by the first east or southeast wind.

The bar was about 600 yards from the outlet.

The depth of river at and near the mouth where cross-sections were made during the survey shows decided changes at the same points at different times, depending upon the presence or absence of rises. The observation of currents in this section of the river gave for greatest observed ebb velocities on the surface 2.4 feet, at mid-depth 1.9 feet per second. The greatest velocities on the flood, on the surface and at mid-depth, were respectively 2.1 and 1.8 feet. The rises of tide during these observations are not recorded.

Major Howell in his letter to the Hon. Galusha A. Grow, which forms a portion of his official report (Report of Chief of Engineers, part 1, 1875, pp. 937, 938, and 939), gives 3⅔ feet as the greatest surface velocity on the flood at the mouth, and he states that on the ebb the velocity was considerably greater though it was not measured. During these observations the greatest rise of tide was 30 inches.

From the Coast Survey Chart it appears that the adopted mean rise and fall is the same as that at Galveston, 1.1 feet.

The cross-sections at and near the mouth vary considerably in depth and contour with the state of the river, and Major Mansfield reports that 10 feet is the depth where most contracted, and this, in his opinion, "indicates the limit of depth to be maintained by natural causes over the bar after jetties are constructed."

The tidal currents would form an important adjunct to the maintenance of the depth of channel between the jetties and over the bar if the velocities observed and recorded could be relied upon as of frequent occurrence; but as these were obtained during a rise and fall much exceeding the average, it is impossible to state what weight to attach to their influence. In the system of converging jetties, as the width between them may be considerable, a long prevalence of inefficient currents might lead to the formation of shoals in the channel between jetties and necessitate the occasional employment of a dredge. A deficiency of current power would also require the ends of the jetties to be planted in deep water to afford security against the early formation of a shallow exterior bar.

Major Howell, in his official report (p. 940, part 1, Report of Chief of Engineers, 1875), states:

> It is now certain that the so-called littoral current at the Sulina mouth, owes its effectiveness, if not its existence, entirely to the winds. It is, therefore, strictly speaking, a wind-current, to which the name littoral has been loosely applied.
>
> We are now assured that at the mouth of the Brazos there is no littoral current, such as was expected within a useful distance from the shore, and that such wind-currents as are found are entirely similar to those at the Sulina mouth.

* * * * * * *

From the comparative chart herewith, it appears that since 1858 the Brazos Bar has not advanced into the Gulf, but has only undergone change in depth and contour, such change as is said to occur once or more each year. This is evidence that deposits from the river are not permanently retained on the bar.

During the season of low-water in the river there is but little or no material carried in suspension by the latter. The river current is then so feeble that the currents across the bar are mainly due to the Gulf tides. This season is usually marked by the prevalence of winds from southeast to southwest, which, blowing on shore, drift the sand of the neighboring gulf bottom in on the shore and bar, and cause shoaling of the latter to that depth the currents across it can just maintain.

* * * * * * *

The season of flood in the Brazos River is also the season of northers. The floods are sudden in their rising, and the northers are the most violent storms known along the coast of Texas. At the mouth of the Brazos the general trend of the coast is such

that the wind accompanying these northern blows along it, very obliquelyto it, or directly off it.

The floods and the northers completely sweep away that portion of the bar formed during low-water in the river by the southerly winds, and drive the material so swept off into the deep water of the Gulf. From this it is seen that the bar is a drift bar, because formed at a time when the river is bringing no deposit to it, and washed away when the river is in flood and most heavily charged with earthy matter, which it is moving toward the bar. It is also formed when the currents, induced by the winds, set on shore, and washed away when the more violent currents, induced by the winds, from an opposite direction, or along shore, prevail.

Major Howell, from the successful application of jetties under conditions similar to those found here, finally recommends their adoption at the mouth of Brazos River.

Reference has thus been made to surveys by the Coast Survey and under the direction of Major Howell, and full quotations furnished of the views of the latter as to the bar formation and the means to be adopted for this improvement. All information contained therein bearing upon the subject has been collated, and as a matter of the history of the case it remains only to refer to the report of Lieut. W. H. C. Whiting, Corps of Engineers (House Ex. Doc., Thirty-third Congress, first session, part II, 1853, 1854).

The bar is like all the bars on this coast, due more to the action of the sea than of the river it obstructs. It is of hard sand, shifting in position and forms somewhat as the stage of water in the river changes; the channel through it always changes after a hard blow.

* * * * * * *

These rises occur during the winter, when the wind is mostly off-shore, giving better water on the bar than during the summer. The bottom, 1 mile from the bar, is blue clay mingled with sand; inside the bar is blue clay mud and sand, the deposts from the river. The anchorage, so far as holding ground is concerned, is good both inside and beyond the bar.

It is quite evident that the amelioration, if any, of the channel over the bar must come from the use of jetties. Whether these shall be converging and spead wide apart at their inshore extremities or made nearly parallel cannot be exactly determined with the information at hand. The average rise and fall of tide of only 1 foot and the absence of a spacious tidal basin appear to confirm the views of Major Mansfield, who states: "We have no tidal reservoir here, and therefore cannot bring the tide to aid us in any plan of improvement." If this be so, the channel between the jetties during the long period of the dry season would likely, in the absence of effective tidal scour, shoal in parts; and to prevent this a concentration of as much as possible of the tidal currents by the jetties should be effected, which would probably lead to the use of jetties nearly parallel. Also, for the same reasons, the jetties should terminate in deep water—18 or 20 feet—to prevent the early appearance of an exterior bar. The position of the jetties should be so chosen as to fix the channel in its natural direction.

The following estimates are based upon the rates furnished in Major Mansfield's report:

ESTIMATED COST.

North jetty, 3,600 feet long, 60,025 cubic yards at $4.69	$281,517 25
South jetty, 4,350 feet long, 41,330 cubic yards at $4.69	193,837 70
Contingencies, 10 per cent	47,535 49
Total	522,890 44

So far this report has referred only to the improvement of the channel over the bar and between the jetties, with a view to open the mouth

of the river for commercial purposes in connection with its navigation above. Incidentally it will prove a refuge to such shipping as can cross the bar; but as the Gulf waves during severe storms will break between the jetties, only small vessels, if any, will dare to enter at such times. Under the supposition that but 10 feet at mean low and 11 feet at mean high water be attained on the bar the value of the improvement in the way of creating a harbor of refuge will not be very great, as vessels of only about 11 feet draft will enter under favorable circumstances. Should the entrance be thus limited in depth after the building of the jetties, and should it further prove variable, shoaling with the low-water periods, a naval station in the river would be essentially useless. It would be premature, therefore, to discuss the question of improving the river above its mouth with a view to create a spacious deep-water refuge for the commerce of the Gulf, or to the preparations needed for a naval station, prior to the experience obtained from the completion of the jetties.

The Board recommends the adoption of Major Mansfield's project for the construction of a portion of the north jetty with the funds now available, and as the exact proposed location of this jetty does not appear upon any map before the Board, it is further recommended that its position be determined by the local engineer in conformity with the general rules laid down in this report.

With the information, however, before the Board it is not a matter of certainty that the north jetty should be first constructed. The channel on entering the Gulf, as delineated in the surveys of 1858 and 1875, was nearly in the direction of the outlet, afterwards bearing more to the eastward. The south jetty constructed of a bent shape to conform generally to the line of channel would, under ordinary circumstances, sustain the discharge, and by regulating its line of direction extend outwards the deep water and obtain beneficial action at an earlier period of the construction. This consideration would, of course, not dispense with the construction of a north jetty, since both are necessary in order to insure the desired improvement in depth as well as to protect the channel-way itself in some measure during heavy storms. These remarks are suggestive merely, there not being sufficient data on record to form a certain opinion, and it is highly probable that this cannot be reached except from long personal experience during the progress of the construction itself. The lengths and consequent amount of cost of the jetties have resulted from the opinion of the Board that it would eventually be necessary to extend the jetties to a depth of 20 feet at mean low-water. This opinion, of course, is destitute of the precision which a direct test at the place could alone afford, and it may be that shorter jetties would fulfil the purpose, though in an estimate it is well to adhere to a supposition not so favorable.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, and Bvt. Maj. Gen.
JOHN NEWTON,
Colonel of Engineers, Bvt. Maj. Gen.
HENRY L. ABBOT,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 8.

IMPROVEMENT OF PASS CAVALLO INLET TO MATAGORDA BAY, TEXAS.

Survey of Pass Cavallo, the entrance to Indianola, Tex., was made in 1871 (see Report of the Chief of Engineers, 1871, pages 526, 531, 533).

Survey of "entrance of Matagorda Bay and the channel to Indianola, Tex.," was made in 1874 (see Report of the Chief of Engineers, 1874, pages 760–765).

Survey of "Pass Cavallo Inlet to Matagorda Bay" was made in 1878 (see Report of the Chief of Engineers, 1879, pages 922–927).

AMOUNTS APPROPRIATED.

August 14, 1876	$20,000
June 18, 1878	25,000
March 3, 1879	25,000
June 14, 1880	50,000
March 3, 1881	60,000
Aggregate	180,000

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1881.

In conformity with the views expressed by the Board of Engineers (pages 1259, 1260, Report of Chief of Engineers, 1880), a project for the expenditure of the funds of appropriations of 1876, 1878, 1879, 1880, in commencing work of improvement at this Pass, was forwarded August 16, 1880. On the 25th of August authority was given to proceed with the work in the manner outlined in the project, viz, to build one jetty of brush and stone or concrete on the south side of channel to the limit of available funds; the work to be done by contract.

In response to advertisement of September 14, 1880, the following bid was received.

Abstract of proposals for improving Pass Cavallo, Tex., in response to advertisement, dated September 14, 1880, *and opened October* 14, 1880, *by Maj. S. M. Mansfield, Corps of Engineers.*

No.	Names of bidders.	Brush in place.	Stone in place.	Small stone, gravel, in place.	Concrete in blocks.	Remarks.
		Per cu. yd.	*Per cu. yd.*	*Per cu. yd.*	*Per cu. yd.*	
1	R. Kanters & Son.....	$9 50	$9 00	$6 50	$7 50	Only bid received.

The bid of R. Kanters & Son was considered satisfactory, and contract was entered into with them, for doing the work required, on the 5th of November; the work to be completed on or before the 1st of December, 1881, and to be limited to $106,000.

Prior to actual commencement of work on the jetty, an examination of the immediate vicinity of the Pass covering the lines of the proposed work was made. The ranges for the line of the proposed jetty as laid down by the Board of Engineers were established on the 8th of January, and on the 11th lines of soundings were taken. This examination discovered a considerable change in the shore-line since the survey of 1878, showing that the ordinary high-tide shore-line had advanced

about 600 feet measured on the line of the proposed jetty, and that an extensive shoaling had occurred near the shore, showing a tendency of the shore to regain the position occupied prior to the storm of 1875. The soundings appeared to indicate that the channel had ceased its southerly advance.

These changes left the shore end of the proposed jetty badly located. The permanent high bank was several hundred feet from its root, so that at any extraordinarily high-tide the water could get entirely around behind it. About 1,150 feet further south the permanent high bank was within 550 feet of the ordinary high-water shore-line. It was deemed advisable to change the location of the inner end of jetty to this point, and build the extension out in an easterly direction until the proposed line (extending southeast) was met. To avoid a sharp angle and consequent danger of eddies, the two lines are to be connected by a gentle curve.

The work under contract proceeded very slowly at first, because of the tardiness in the delivery of all material, owing to the rough weather. To date (inclusive of June 30), the condition of the work on south channel jetty is as follows:

From the initial point on shore, at the base of the permanent high bank, the foundation-course of mattresses has been extended 958 linear feet. Of this extension there is a length of 565 feet on shore, and the excavation for this work is 18 inches deep on the sides, making the mattress-work when finished 2 feet higher in the center than at sides, giving the work a mound-like form in section. The rest of the extension is in water $1\frac{1}{2}$ feet to 2 feet.

The inshore work commences with mattresses 25 feet wide, and gradually increases in width along the jetty until at about the water-line the work is 60 feet wide. The average thickness of mattress on shore is 3 feet, in water $2\frac{3}{4}$ feet. For the entire length of work the protective covering has consisted of a mixed ballast of stone and concrete.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Continuation of work on jetty extension of foundation-course under the contract of November 5, 1880, with R. Kenters & Son, to the limit of funds applicable thereto, when the expenditure of the funds of act approved March 3, 1881, will commence. The work to be in continuance of the present work, and to be done by contract, if suitable bids are received in response to advertisement bearing date of June 20, 1881, the bids to be opened July 20, 1881, and contract to be awarded thereafter.

This work may be simply to extend the foundation-course of mattresses, or to extend and at the same time raise the jetty to a higher level, or to place stone or concrete alone upon the work already laid, as may be deemed necessary during the progress of the work.

ORIGINAL ESTIMATE.

Report of the board, 1879	$1,039,180
Appropriated 1876, 1881	180,000
Unappropriated balance	859,180

Of which sum $200,000 can be profitably expended during the fiscal year ending June 30, 1883, in constructing the south channel jetty as projected.

The work is located in the collection district of Indianola, Tex., and near Matagorda light-house.

Money statement.

July 1, 1880, amount available	$117,131 80	
Amount appropriated by act approved March 3, 1881	60,000 00	
		$177,131 80
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	29,453 41	
July 1, 1881, outstanding liabilities	87,678 39	
		117,131 80
July 1, 1881, amount available		60,000 00
Amount (estimated) required for completion of existing project		859,180 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		200,000 00

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, INDIANOLA, TEX.,
Collector's Office, July 9, 1881.

SIR: Owing to a pressure of official business, there has been some necessary delay in answering your letter of 1st instant.

I have now the honor to inform you that the number of vessels and their tonnage engaged in the foreign and coastwise trade entered and cleared at this port during the year ended June 30, 1881, are as follows, viz:

FOREIGN TRADE.

Class.	Entered.		Cleared.	
	No.	Tonnage.	No.	Tonnage.
Steam vessels	22	23,750.64	32	34,209.50

COASTING TRADE.

Steam vessels	110	119,620.17	14	7,972.43
Sail vessels	20	2,627.83	30	1,551.59
Grand total	152	145,998.64	76	43,732.52

I beg to state that the tonnage given represented only the tonnage of vessels that reported to this office. There are many vessels that arrive and depart from this district that are not required, under the law, to either enter or clear at the custom-house.

I am, very respectfully, your obedient servant.

CHARLES R. PRONTY,
Collector.

O 9.

IMPROVEMENT OF ARANSAS PASS AND BAY UP TO ROCKPORT AND CORPUS CHRISTI, TEXAS.

Survey of Aransas Pass was made in 1871 (see Report of the Chief of Engineers, 1871, pages 528–531).

Survey of Aransas Pass and Bay up to Rockport and Corpus Christi, and Corpus Christi Pass and channel, was made in 1878 (see Report of the Chief of Engineers, 1879, pages 928–937).

AMOUNTS APPROPRIATED.

Act of March 3, 1879	$35,000
Act of June 14, 1880	65,000
Act of March 3, 1881	80,000
	180,000

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1881.

In accordance with the views expressed by the Board of Engineers, the work under the appropriation of $35,000 (1879) was continued by hired labor and purchase of material in open market.

The "forming platform" was completed and the first mattress begun on the 13th of July, and by the 7th of August, the Harbor Island jetty was extended to 20 feet depth of water, its length being 246 feet, and 2 groin-jetties were in progress off the head of Mustang Island.

On the 16th of August the assistant engineer in charge reported having passed through a severe storm, with consequent loss and delay of the work. By the recovery of nearly one-third of the brush, all the lumber in mattress-platform, and nearly all stranded material, the loss was somewhat reduced. Immediately after the storm, a number of small mattresses (12 by 22 feet) were placed—strengthening the groins, and starting groin No. 3 to aid in recovering the head of Mustang Island, which had been greatly eroded by the storm.

A project for the continuation and prosecution of the work under the appropriation of $65,000 (1880) was rendered August 24, 1880, viz:

PROJECT FOR CONTINUING IMPROVEMENT, ARANSAS PASS, TEXAS.

Appropriation approved June 14, 1880 ..... $65,000

The work at present is being done under the appropriation of $35,000, act of 1879, in accordance with the recommendations of the Board of Engineers, report of August 9, 1879. It is in very satisfactory progress while a little more than one-half of the appropriation has been expended. Considerable material had been accumulated and was being rapidly worked up with very marked and beneficial results, when the severe storm (cyclone) of the 11th and 12th August overtook us, causing a loss of about 800 cords of brush—partially recoverable—and a delay in our progress, but in no way disturbing our completed work, which thus had a severe test and had the undoubted effect of retaining the pass in its present position. But for our work I am convinced the head of Mustang Island would have been swept away so as to have entirely obliterated Turtle Cove. The channel has now deepened to 8 feet, which will enable the Morgan steamer to resume its trip to Corpus Christi and Rockport.

We shall undoubtedly hold this channel and improve it greatly.

I recommend the continuance of this work, which has such a promise of good results, as at present, by hired labor and purchase in open market.

We can work here much more economically and satisfactorily, now that we are established, than can any contractor, and I do not think it possible to find any party who will take the contract in the interests of the government.

I believe it would be injurious to the public interest to attempt to do this work by contract at the present time, for it is a class of work with which few persons are acquainted, and it would probably not be undertaken by any one except with a very large margin of profit and loss.

The attempt to contract for this class of work will soon be made at the mouth of the Brazos River and at Pass Cavallo, provided my projects for these works recently submitted are approved.

Respectfully submitted.

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., August 24, 1880.

The operations of this project to be conducted in accordance with approved recommendations suggested in my letter of July 30, 1880, to the Chief of Engineers, viz, to protect the head of Mustang Island from further erosion and to construct the south-channel jetty.

LETTER OF MAJOR S. M. MANSFIELD, CORPS OF ENGINEERS, OF JULY 30, 1880.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 30, 1880.

GENERAL: I have the honor to submit some remarks upon the improvement of Aransas Pass, Texas, for your consideration.

Under the authority contained in letter from your office of April 10, last, work of preparation began immediately. Experiencing considerable difficulty incident to the beginning of a new work of such magnitude, one obstacle after another was overcome till we are now in good working order, having comfortable buildings for the accommodation of officers and about 40 men, a fine supply of brush and stone (of indifferent quality) on hand, and unlimited quantities to come in as we may require, and are consequently in condition to push the work rapidly. I have adopted the exact methods of the Dutch, and am now building the Harbor Island groin, while protecting as far as possible the sand-spit of Mustang Island from wearing away and exposing Turtle Cove. This cove furnishes us with an excellent place for receiving material and manufacturing same into mats in close proximity to our work. I see no reason now why our work should not progress with a fair prospect of securing an improved channel over the bar with the available funds.

My mistake in letter of March 30, submitting project for this work, in assuming General Newton's project as the project of the Board, is freely admitted. I cannot but think, however, that the mistake is not wholly inexcusable.

The Board had under consideration the harbors or inlets upon the coast of Texas, and prefixed their report upon each inlet with the same general discussion of the action of the winds and tides upon the characteristic formation of the coast, and pointed out agreements in certain prominent features, and concluded with laying down the principles that should govern in any plan of improvement for these inlets. They then discussed each inlet by itself, and submitted projects for the improvements.

Regarding Aransas Pass, the project of the Board to construct two jetties to contract the outflow and to protect with groins or mattresses the head of Mustang Island was a natural following of the governing considerations and principles for planning the work; but the further recommendations as to order and sequence of the work seemed to be at variance with the law they laid down and not answering to any special features of this inlet.

General Newton's recommendations did not appear in the form of a minority report, and to my mind they harmonized exactly with the general governing principle and with the special feature of this Pass, and I unwittingly fell into the error of assuming General Newton's project as a project of the Board, and was not conscious of error till it was called to my attention in letter from your office of April 10.

The Board concludes its general remarks with this:

"There have been almost no opportunities for experience, valuable as precedents, along this coast, and the conditions are so variable with time that a large margin should be left to the study and intelligence of the constructing officer on the ground."

I have now been in charge of the work contemplated to be done on this coast five months, and have made a very careful study of the problems presented for my consideration, giving them my undivided attention. The work at Aransas offers the prospect of the earliest attainment of success and has received especial attention. I have refrained thus far from expressing any views thereon till I could visit the locality and have further assurance of the position I feel obliged to maintain.

I have no desire to antagonize the Board of Engineers, but I must respectfully differ with the majority of them as regards the order of work at Aransas Pass.

I have just returned from the Pass, and have the honor to submit herewith a tracing showing approximately the changes that have taken place since Collin's survey.

The point of Saint Joseph's Island has expanded and moved west some 500 feet.

About 500 feet of sand-spit, northeast end of Mustang Island, has been cut off to several feet below water, and the water has broken through at about the position of the third groin. This break we have closed, and the whole shore-line from this point to the position of the jetty is making out under the influence of southwest winds, especially near the jetty. Beyond the shore-line out to the wreck water is very shoal, and this line is crossed by a very narrow channel of 6 feet. The wreck is the nucleus of a long shoal extending southward, and incroaching upon this channel, now quite closed in accordance with a natural law. The new channel has just opened to the eastward, and during my presence there the steam and sail vessel Sidbury, a large four-masted schooner, passed over the bar (on the dotted line), drawing 5 feet.

I accompanied the pilots out over the bar, and sounded all over the Pass. Pilot Mercer, a very intelligent man, with twenty-five years' experience at this inlet, accompanied me in my inspection of both islands, and pointed out the great changes that have occurred in his time. From his observations of years he is, and always has been, of opinion that the Mustang Island jetty should be first constructed. This is the view taken by every one acquainted with the place.

Suppose we build the Saint Joseph's Island jetty first, as recommended by the Board, it will not in any way stop the erosion of Mustang Island, and the channel will continue to move to the westward, and our work will be left like that of 1869. Will it in any way support the ebb-current? Not at all, for Mr. Collins, in his notes of the survey, says (page 17, Report of the Board):

"From observations of the tides at Aransas Pass, the Gulf waters, breaking even on quiet days upon the flat between Saint Joseph's Island and the wreck of the Mary," were carried in during the flood gray with sand, which was deposited by the time the current reached the light-house. The flood-tide currents were formed only from the surface to about mid-depth of the passes, for the rest of the depth there being no current. On the ebb, the current in the channel abreast the head of Mustang Island, was about as strong near the bottom as at the top;" and the notes of the survey also state that, "none of the water runs over the flat where it came in."

If this jetty is to be built at all it should be a low jetty to serve as a training-wall after the other jetty (a high one) is completed, and it should offer as little obstruction as possible to the flood-tide current.

I advise the protection of the head of Mustang Island from further erosion, and the construction of the west jetty occupying a line east and west (magnetic), passing to the wreck before turning seaward. This wreck now occupies about the point of crossing of lines drawn tangent to the shore-lines of Mustang Island. It will furnish a permanent support to a most exposed point of our work, and will obviate the necessity of its removal, which would be a costly undertaking. It is expected the sand will rapidly accumulate about this jetty on the seaside; the water here is shoal for the whole distance, and the proximity of our material assures us of easy and rapid construction, and promises an early improvement of the channel over the bar.

I earnestly ask for authority to conduct the work in the order I here suggest. Great interest is shown in the progress of our work by the large business houses located about Aransas and Corpus Christi bays. I cannot foresee any benefit to be derived from the building of the Saint Joseph jetty until after the Mustang Island jetty is well carried out. In fact, it is not difficult to see that the Pass will move entirely away from the Saint Joseph jetty before much of it can be completed, and perhaps before Congress shall grant further aid.

It is necessary, for the best possible good to be derived from the present and future appropriations, to maintain the Pass in its present position.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Col. U. S. A.

The CHIEF OF ENGINEERS, *U. S. A.*,

During the year all work has been done by hired labor and purchase of material in open market; the work designed and constructed in the year being as follows:

1. A breakwater was built along the channel face of Mustang Island for a length of 870 feet, closing a break through the sand-spit at the northeast end of the island; and, forming a base of the groins (Nos. 1, 2, and 3), additions were made in extending, widening, and raising this work from time to time.

2. Seven groin jetties were built on the west side of the Pass, to protect the head of Mustang Island up to and beyond Turtle Cove, viz:

First jetty being the one located and running out from Harbor Island 450 feet in length.
Second jetty (No. 1) 255 feet long.
Third jetty (No. 2) 124 feet long.
Fourth jetty (No. 3) 270 feet long.
Fifth jetty (No. 3½) 90 feet long.
Sixth jetty (No. 4) 170 feet long.
Seventh jetty (No. 5) 284 feet long, with wing of 150 feet.

3. Sand fences were built on Mustang and Saint Joseph islands to catch the sand and prevent it from being blown into the channel. The

number of running feet of fences on Mustang Island is 4,950; on Saint Joseph Island, 2 miles. In the successive "northers" of the fall and winter it was reported that these fences served their purposes admirably.

4. The work on the south channel jetty, connecting the shore with the wreck of the Mary, was commenced in February, 1881, the inner end beginning at the shore, the line of work running north 87° east. At the close of June there were placed in the foundation course of this jetty—a length of 2,200 feet—sixty mattresses of brush work, of which number, five were 2 by 29 by 44 feet and fifty-five were 2 by 32 by 56 feet. The ballast used consists entirely of stone, furnished by various parties from the adjacent country within a limit of 75 miles of the Pass.

A survey of the bar is now being made by Assistant Engineer, Mr. W. L. Webb, who has charge of the work now progressing in the most satisfactory manner under his able management.

It is expected a marked improvement of the channel over the bar will result from the fall storms.

For the first seven months of the fiscal year the plant needed at the Pass was hired. Having thought it best to build a couple of barges and to repair our launch "Survey," to aid in the work of improvement, authority was asked (and given) to do so. In January, having undergone a thorough course of repair at our yard at Bolivar Point, the launch was at the Pass, and in February the two barges were ready for work. Some difficulty was experienced in obtaining a practical man to run the launch's engine, and the consequent breakage to its machinery tended to hinder the work, especially so in April and May. This, however, was overcome by my action in dispatching the United States tug "Molyneux" from Galveston to take the place of the launch temporarily, so that the work might continue on the south-channel jetty without serious interruption.

During the year the work of improvement was further impeded by the storm of August 11 and 12, by striking laborers in October, and by unfavorable weather in November, January, February, March, April, and the first half of the month of May.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882.

Project for the application of the funds of the last appropriation, $80,000, was made; and, in accordance with the views expressed by the Board of Engineers, it is intended to continue the work on the south-channel jetty; labor to be hired; incidentals to be purchased in open market, and brush, stone, and cordage to be procured by contract, if possible.

Advertisement dated June 7, 1881, invites bids; bids to be received and opened July 6, for furnishing 2,250 pounds marline, 4,500 cords brush, and 4,500 tons of stone for this work.

ESTIMATES.

For the Pass:

North jetty	$344,000 00
South jetty	293,950 00
Groins	26,400 00
Shore protection	24,000 00
Contingencies, 10 per cent	68,835 00
Planting trees on Saint Joseph's Island	2,000 00
Aggregate	759,185 00

For the Bay:		
Major Howell's report, 1879		$441,537 75
Aggregate		1,200,722 15
Appropriated		180,000 00
Unappropriated balance		1,020,722 15

Of this amount $200,000 can be very profitably expended in the fiscal year ending June 30, 1883, in constructing works in accordance with the approved plans for the improvement of the Pass.

The work is located in the collection district of Corpus Christi, and the nearest light-house is at Aransas Pass.

The following extracts from a personal letter from Col. G. W. Fulton, dated January 3, 1881, speaking of Aransas Pass, might appropriately be inserted here:

It should be remembered by all that the currents of the present season have been less favorable for cutting the bar than any other for the last 12 or 14 years, and we shall have to depend upon the flood-tides for cutting until the absence of rains shall enable the bay to resume its wonted saline qualities, which will not now be until late in the fall. I am gratified at the building out of the sand-spit, and hope you will be able to secure it by midsummer, before the autumn storms; if so, it will save a large amount of money. The Aransas came in this trip without hinderance, drawing 7 feet 11 inches, and a norther blowing and very low water in the bay.

* * * * * * *

That the present work is doing good service is evidenced by the fact than the channel over the bar has been more steady in position than ever before; it has varied less in the past 4 months than ever before; it deepens slowly but steadily, which is accounted for by the fact that there is not at present, and has not been since August, any cutting by the ebb-tide.

* * * * * * *

Money statement.

July 1, 1880, amount available	$92,305 01	
Amount appropriated by act approved March 3, 1881	80,000 00	
		$172,305 01
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	88,693 55	
July 1, 1881, outstanding liabilities	3,611 46	
		92,305 01
July 1, 1881, amount available		80,000 00
Amount (estimated) required for completion of existing project		1,020,722 15
Amount that can be profitably expended in fiscal year ending June 30, 1883		200,000 00

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, CORPUS CHRISTI, TEX.,
Collector's Office, July 7, 1881.

SIR: In response to your letter of 1st instant, asking tonnage of vessels crossing Aransas Bar, I have the honor to state that there have, during the year ended June 30, 1881, vessels entered Aransas Bay over Aransas Bar as follows: 62 steamers and 201 sailing vessels; aggregate tonnage, 66,878 tons. This does not include the vessels anchored outside the bar and lightered, nor does it include the lighters.

Very respectfully,

SAM. M. JOHNSON,
Collector.

Col. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

LETTER OF DODDRIDGE & DAVIS.

CORPUS CHRISTI, TEX., *July* 19, 1881.

DEAR SIR: The following is a statement of the imports and exports of this place, which I trust will serve your purpose:

IMPORTS.

Lumber	feet..	7,000,000
Shingles	number..	1,333,000
General merchandise	barrels..	200,000
Railroad iron, in tons, 6,600, or	in pounds..	13,200,000

EXPORTS.

Wool	pounds..	5,612,641
Dry hides	do....	1,065,579
Dry skins in bales	do....	700,752
Horse-hair	do....	26,156
Wet salted hides	do....	75,000
Bones	do....	50,000
Tallow	do....	12,000
Horns	do....	2,260
Sheep	number..	1,416
Mules	do....	35
Horses	do....	86
General merchandise	barrels..	1,031
Cotton (raised in this locality)	bales..	262
Copper (ingots)	pounds..	12,982

DODDRIDGE & DAVIS.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

Table of arrivals and departures of vessels at Aransas Pass, Texas, from July, 1876, *to June,* 1881, *inclusive.*

Month.	1876.					1877.					1878.				
	Steam.		Sail.			Steam,		Sail.			Steam.		Sail.		
	Arrivals.	Departures.	Arrivals.	Departures.	Depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Depth of water on bar.
July	6	6	11	12	8½	6	7	11	12	10	6	6	16	13	9
August	7	7	19	18	8½	7	7	17	18	10	7	9	12	13	9
September	8	7	8	9	11	8	7	8	9	10	11	10	15	18	8½
October	7	6	16	13	11	7	6	13	13	10	13	14	19	16	8
November	7	8	11	12	11	7	8	11	12	10	10	9	13	15	8
December	8	7	17	13	11	8	7	18	13	9½	11	10	8	12	7½
January	6	6	8	11	11	6	6	8	11	9½	7	8	20	17	7½
February	6	5	12	13	11	6	5	12	13	9½	7	4	20	14	7½
March	3	4	13	11	11	4	5	12	10	9½	6	7	12	20	7½
April	6	7	26	20	10½	3	3	11	7	9½	3	5	10	11	7½
May	9	8	10	13	10½	7	5	9	16	9½	4	3	22	23	7½
June	8	8	13	11	10	5	6	15	15	9	3	4	17	14	7½
Total	91	79	164	156	....	74	62	145	149	....	88	89	184	186	....

Table of arrivals and departures of vessels at Aransas Pass, &c.—Continued.

Month.	1879.					1880.					1881.				
	Steam.		Sail.		Depth of water on bar.	Steam.		Sail.		Depth of water on bar.	Steam.		Sail.		Depth of water on bar.
	Arrivals.	Departures.	Arrivals.	Departures.		Arrivals.	Departures.	Arrivals.	Departures.		Arrivals.	Departures.	Arrivals.	Departures.	
July	4	4	13	13	7	....	....	2	9	5	1	1	12	7	6
August	1	1	16	9	7	....	....	13	10	5	2	2	13	9	6
September	2	2	6	11	7	....	....	11	13	5	6	5	7	5	7
October	3	2	2	1	7	....	....	12	11	5½	10	6	17	12	7
November	2	3	12	9	7	....	....	15	8	5½	4	4	7	9	7
December	....	....	10	5	5½	....	....	13	20	5½	5	5	16	16	6
January	....	....	12	10	5	....	....	14	16	6	5	5	20	20	7
February	....	....	16	19	5	3	2	11	8	6	5	5	16	26	7
March	....	....	23	22	5	2	3	6	9	6	4	4	17	16	7½
April	....	....	21	19	5½	....	....	10	5	6	11	10	23	12	7½
May	....	....	11	8	5½	....	....	28	28	6	10	12	11	19	7½
June	....	....	14	14	5½	....	....	12	10	6	11	9	8	3	*8
Total	12	12	156	140	....	5	5	147	147	...	74	68	167	154	....

*One vessel entered drawing 8 feet 2 inches.

LETTER FROM COLEMAN & FULTON PASTURE COMPANY.

ROCKPORT, TEX., *July* 24, 1881.

DEAR SIR: The following is a statement of our receipts and shipments, made out for you as requested.

For twelve months our receipts of merchandise per steamships at this port will amount to, say, 4,800 tons; by sail vessel touching here and with frieght for Saint Mary's fully as much, say, 4,800 tons; lumber for Saint Mary's, not far from 1,000,000 feet; our shipments of cattle is a fraction under 14,000 head.

These figures (except the cattle) we believe to be rather under than over the actual amount.

COLEMAN & FULTON PASTURE COMPANY,
SAM J. SEYMOUR, *Secretary and Treasurer.*

Col. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

O 10.

IMPROVEMENT OF HARBOR AT BRAZOS SANTIAGO, TEXAS.

Survey of this harbor and pass was made in 1871, January 28 to March 13, and report, with plan and estimates, was rendered April 7, 1871.

An appropriation of $6,000 (1878) was expended in removing from the harbor the obstruction occasioned by the wreck of the bark Rene des Mers.

The appropriation of $25,000 (act of June 14, 1880), was held to await further action by Congress, the amount being inadequate for commencement of the work.

The appropriation of $75,000 (act of March 3, 1881), in conjunction with the amount given by act of 1880, will be sufficient to make a commencement of the work of improvement at this point and in the manner hereafter outlined.

PROGRESS MADE DURING THE YEAR.

In anticipation of the expenditure of the $100,000 available, a reconnaissance of Brazos Santiago Pass, from the bar in the Gulf to Point

Isabel in Laguna Madre, with a view to project a plan of improvement for navigation there, was made in the month of June, 1881.

A special report covering all the items of interest required, together with plan and estimates for the improvement of the harbor and bar at Brazos Santiago, was rendered June 28, and was as follows:

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 28, 1881.

GENERAL: In submitting my project herewith for the improvement of the harbor of Brazos Santiago, Tex., under the combined appropriations of—

1880	$25,000
1881	75,000
Total	100,000

I do so with some hesitancy, feeling sensible of the difficulties attending the inauguration of a work of this character in this locality where the sea is generally rough, where materials for construction are not readily obtained, and where labor is difficult to manage.

On the 6th of January last I submitted to your office a report upon this contemplated improvement, with a plan and estimate. I have since given the subject a great deal of thought, and have instituted inquiries in every possible direction for information bearing upon the whole subject of the improvement, especially with reference to suitable materials for the work, and recently sent my assistant, Mr. Ripley, to make a reconnaissance in the neighborhood.

His report is very full, and is submitted entire as confirmatory of the views expresed in my letter of January 6.

Mr. Ripley makes a revised estimate of the cost of such a work, in which I concur.

The estimate being about $5 per cubic yard for brush and stone in place, making for—

The south jetty	$190,901 75
The north jetty	129,203 75

It is difficult to estimate closely for a work of this character when so much depends upon the weather.

The cost of this kind of work at Galveston from January 1 to May 31, without considering the cost of plant, has been $2.90 per cubic yard. I think the above estimate of $5 the cubic yard will not be far from correct.

The first appropriation of $25,000 was for improving the bar, the second appropriation of $75,000 was for improving the bar and harbor of Brazos Santiago.

The construction of the dam in the lagoon seems to be an essential feature in the plan of improvement, not so considered in my former report, both for increasing the depth of water on the bar, and in the channel up to Point Isabel, and will render the improvement of the bar permanent; at the same time it will increase the harbor capacity and afford a good channel up to point Isabel. Its construction, however, should not be undertaken until funds sufficient for its completion are in hand; its cost being estimated at $327,979.

IN CONCLUSION.

I would build the south jetty first, then the dam in the lagoon, and finally the north jetty.

The experience gained in this kind of work the past year at various points on this coast shows no difficulty of construction that cannot be readily overcome.

At Galveston 8,000 feet of foundation mattresses, from 60 to 90 feet in width, have been laid, and at Aransas Pass over 2,000 feet, 56 feet in width have been laid from the beach line directly out into the gulf without loss of material and without any apparent settlement. The same thing can be done at Brazos Santiago; but delays and mishaps will be likely to attend the commencement of such a work there, and the cost at first will be greatly enhanced. If done by contract, these chances will have to be paid for, as no prudent contractor will fail to consider them in making his proposals.

I would recommend that the expenditure of the $100,000 in hand be made by commencing the work in accordance with the above views, and that the work be offered to contract in the usual manner.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1882,

Will depend upon the action which may be taken regarding the report above given. Actual work upon the improvement could be undertaken this fall, and a fair beginning made upon the south jetty with the funds in hand.

ESTIMATE.

Plan submitted awaiting approval:	
South jetty	$190,901 75
North jetty	129,203 75
Dam	327,979 00
Plant	30,000 00
Total	678,084 50
Appropriated	100,000 00
Unappropriated balance	578,084 50

Of which amount $200,000 can be profitably expended in constructing jetty, &c., during the fiscal year ending June 30, 1883.

The work is not considered as susceptible of permanent completion and estimates will vary accordingly.

It is located in the collection district of Brownsville, Tex., and the nearest light, Brazos Island light (beacon).

Money statement.

July 1, 1880, amount available	$25,000 00	
Amount appropriated by act approved March 3, 1881	75,000 00	
		$100,000 00
July 1, 1881, amount available		100,000 00
Amount (estimated) required for completion of existing project		578,084 50
Amount that can be profitably expended in fiscal year ending June 30, 1883.		200,000 00

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 21, 1881.

COLONEL: In accordance with your instructions of the 20th ultimo from which I make the following extracts—

"You will proceed by steamer to-morrow to Brazos Santiago and Brownsville, Tex., and make a reconnaissance of Brazos Santiago Pass, from the bar in the Gulf to Point Isabel in Laguna Madre, with a view to project a plan of improvement for navigation there under an appropriation by Congress of $100,000. You will examine the country thereabout and make all necessary inquiries about material applicable to our work, its cost and facility for handling. The labor question should also receive your attention. While at Brownsville you will please examine the work executed there last season for the protection of the river bank. * * *

"Upon completion of this duty you will return to Galveston, Tex., and report"—
I have the honor to make the following report:

As it was not possible for me to make any extended observations, I availed myself of every opportunity to obtain information from those most familiar with that section, and devoted my personal endeavors in a great measure to the verification of this information.

Capt. George Staples, of the Morgan steamer J. C. Harris, who has many years' acquaintance with both Brazos Santiago and the mouth of the Rio Grande, says that the littoral current is governed to a great extent by the direction of the wind. The southeast trades, which blow during the summer months, produce a northerly current along the shores of Brazos and Padre islands. The current has this direction about nine-tenths of the time. The northers of winter produce a current in the opposite direction. Captain Staples also says that the ebb and flood currents in the pass at times are very strong, making it necessary to let go two anchors to keep his ship from

dragging. An observation for velocity of the flood current, taken May 29 by Lieutenant Sebree, of the Navy, in command of the United States Coast Survey steamer Gedney, gave a velocity of 3.8 miles per hour.

Captain Staples further says that clay bottom is found in 18 feet of water in the pass and in the Gulf anchorage just off the bar; but on the bar the bottom is all hard sand, which is easily shifted, as was shown by a recent occurrence. The pilot attempted to take the steamer (Harris) in on a falling tide. She was drawing 8 feet 2 inches, and struck the bar with but 7½ feet alongside. The tide continued to fall until there was but 6½ feet alongside with a strong ebb current running. In this condition she was brought head on to the current by means of an anchor, and by working her engine ahead the sand washed away from her bottom and sides sufficiently to let her cross the bar, drawing 1 foot and 8 inches more water than was on the bar at the time.

Pilot Baker says that the deepest scour on the bar has never revealed anything but sand.

The pilots as well as Captain Staples say that a strong norther always improves the water on the bar, by forcing the water rapidly out of the lagoon, and thus increasing the ebb current and consequent scour.

Northers and especially northeasters make it very rough on the bar. It is the opinion of Captain Staples that there is more rough weather at Brazos than at any other Gulf port.

From Mr. Deer and Captain Stow (employés of the Rio Grande Railroad Company), pilots Baker and Hill, and other residents of Point Isabel, I learn that a strong norther raises the water in the lagoon at Point Isabel about 3 feet above ordinary tide, producing strong currents out of Brazos Pass down the lagoon towards Boca Chica, and out Boca Chica, often increasing the depth of water at the latter place from 1 or 2 feet to 12 feet. Mr. Gelston, of the firm of Woodhouse & Co., says that during the Mexican war large steamers with screw propellors crossed the bar without any delay; and Capt. Henry Miller, proprietor of Miller's Hotel at Brownsville, who is a retired sea captain, says that in 1840 there was 18 feet of water on the Brazos Bar.

There are at present two channels across the bar of nearly equal depths. The direction of the main channel is nearly east, and has a depth of 7 feet at low-tide; the direction of the other is southeasterly, and has a somewhat less depth. This channel is a temporary one, and often becoming closed, a similar channel breaks through to the northeast, so that there are generally two channels in existence—the main one, and one either north or south of it.

The material in the lagoon between Point Isabel and the pass is a mixture of sand and clay; the nearer the pass the greater is the proportion of sand. Further south, towards Boca Chica, the bottom is very soft mud. Dr. Wolf, the quarantine doctor at Brazos, says that Brazos Island, except a few feet of the surface (which is sand), is composed of stiff clay, suitable for bricks. At Point Isabel there is a ridge lying northeast and southwest, about 30 feet high, upon which the light-house is situated, which is compased of clay. Where this ridge projects into the lagoon the earth stands nearly vertical. Between Point Isabel and Brownsville numerous ridges are to be met, all having the same general appearance, indicating an ancient geological condition very different from the present.

The general impression prevails among persons acquainted with the harbor that it is being filled with sediment from the Rio Grande. To ascertain the grounds of this belief, and prove if possible the truth or falsity of it, I made a personal reconnaissance of the country from the river to the pass. At the time of this reconnaissance the river was at a stage about 3 feet above low-water, having fallen recently from a 10-foot rise to this stage. At a point about 12 miles by land from Brownsville there is a crevasse, known as Luloso Bayou, 150 feet wide and 8 feet deep, with a velocity of current of 2 miles an hour (roughly measured). At low-river the depth is 5 feet, and at high-river 13 feet, before the banks become submerged.

The accompanying tracing, marked A, is from a lithographic chart of a survey made in 1847, the original of which is in the possession of Mr. S. W. Brooks, of Brownsville. Since this survey, the shallows extending from San Martin to Partrero Circado have been filled to a depth of several feet with sediment from the river. Bayou Tuloso runs in well-defined banks from the river to the Portrero Circado, the depth varying from 8 feet at the river to 2½ feet at the Portrero Circado at low-tide. From the latter place to Laguna Madre the bayou spreads out and becomes very shallow, having but 6 inches depth at low-tide, and has a deposit of 12 to 18 inches of very soft mud. The crevasse at San Martin has been many years closed; that at Tuloso broke through in 1870, and it is probable that the filling of the shallows has mostly been accomplished in the past 11 years. At high-river the banks of the bayou are overflowed, and the principal deposit occurs near the river; at lower stages the sediment is carried further down the bayou, and at low-river it is poured directly into the lagoon. In this way the banks of the bayou are elevated and extended at every rise of the river. During high-river the quantity of water finding its way from the river to the lagoon through this bayou

and over the banks at other points further down is so great that the fresh water reaches and finds exit at Brazos Santiago.

There is also another way in which the river sediment may find a lodgment in the harbor, though probably to a very limited extent. The water from the river, after reaching the Gulf by its natural mouth, is often carried by the littoral current beyond Brazos Santiago. During flood tide a portion of this water must enter the harbor and deposit its sediment there. On the 22d of May, the day of my arrival at Brazos, a streak of muddy water from the mouth of the river was distinctly traceable at the pass, and Lieutenant Sebree, of the United States Coast Survey steamer Gedney, has often noticed the same phenomenon.

A comparison of the Coast Survey chart of 1867 with the survey of 1871 by Lieut., now Capt. H. M. Adams, shows that the greatest depth in the pass has diminished from 40 feet in 1867 to 27½ feet in 1871, and the width between the 12-foot contours has diminished from 540 feet to 350 feet. At present Captain Staples says there is but 20 feet depth anywhere in the pass.

Another evidence of the harbor filling is shown in the formation of a middle ground between Point Isabel and Brazos, leaving a channel on either side of it. The depth of water in these channels is about the same as was to be found anywhere between Point Isabel and Brazos in 1867 (see tracing marked B), while on the middle ground and north and south of the channels there has been a shoaling.

CONCLUSIONS.

The conclusions which may be legitimately drawn from the information obtained are—

1st. A littoral current exists, the prevailing direction of which is north, but during northers its direction is south.

2d. The bar is composed of sand to a probable depth of 12 to 18 feet from the water surface.

3d. There is undoubtedly sufficient current, if concentrated on the bar, to scour and maintain a depth of 12 feet or more.

4th. The mean rise and fall of the tide being but 0.7 of a foot, the ordinary velocity of current in the pass must be very small compared with the velocity during northers; hence any plan of improvement, to be effectual to its fullest extent should be so devised as to get the full benefit of the current caused by northers.

5th. During northers a large percentage of the water of the lagoon is lost to Brazos by being driven by the pass and banked up in the lower end of the lagoon, filling the numerous shallows in that vicinity and finally discharging through Boca Chica.

6th. The harbor is gradually though surely being filled by deposits from the river, and the rate of filling will be increased from year to year as the banks of Tuloso Bayou become raised above ordinary rises of the river and so prevent the escape of the sediment which it carries until it reaches and is poured directly into the harbor. The harbor becoming filled, Brazos Santiago will be conjointly one of the mouths of the river, and a pass from the lagoon to the gulf, as Boca Chica now is, and will dwindle into insignificance except at periods of storms or severe northers, when it is probable that a channel sufficient for the purposes of navigation may be maintained for a short time. It is evident, therefore, that any plan of improvement, to be permanent, must contemplate the complete exclusion of the river water from the harbor and pass.

7. We have seen that the Rio Grande forms an important factor in devising a scheme of improvement for Brazos Santiago. Anything therefore relating to the physics of the river is pertinent to the subject.

The Rio Grande is eminently a sediment-bearing river. At all stages its waters are heavily charged with sediment.

There is one peculiarity which is possessed by few if by any other rivers to the same degree, and that is the rapidity with which the suspended particles will subside when the water is brought to a perfect state of rest. Mr. Latimore, of Brownsville, who supplies the inhabitants with river water, says that he fills his tanks in the evening and in the morning following it is perfectly clear and ready to draw off and deliver to his customers.

For many miles from its mouth the river flows through a valley of its own deposit. Through this valley it winds its way making the average distance between two points by river about three times as great as by land. Like the Mississippi River, it has its shifting sand-bars and deep reaches, its caving banks and battures, its cut-offs and crescent lakes. At its mouth is found the inevitable bar with an average depth upon its crest of about 4 feet.

Samples of sediment taken from the river bank at Brownsville and from Laguna Madre about 1 mile south of Point Isabel have a very similar appearance. Each sample is composed of a very fine calcareous sand with a small amount of clay. That from the

river bank has a pinkish tint and contains a larger proportion of clay than the other. That from the lagoon has a bluish-gray color. When dissolved in water and the water poured off, so as to eliminate the clay, the residue from both look exactly similar.

It is to be regretted that so little of the physical history of the river is known. It would be of interest in this connection to know why the river, being a sediment-bearing river, is not also a delta-forming river, if such be really the case. It seems probable that the river at one time debouched into Laguna Madre and that in process of time it has extended its delta, cutting the lagoon in two and thus separating Laguna Madre of Texas from Laguna Madre of Mexico.

Supposing such to have been its history, will it continue its delta into the Gulf, or are its deposits swept away by the littoral currents of the Gulf? In the latter case the improvement at Brazos Santiago must be modified to meet the conditions.

PLAN OF IMPROVEMENT.

If the foregoing conclusions are even approximately correct, the general plan of improvement is quite obvious.

It should consist, in addition to the jetties already proposed and which are shown on the tracing marked C, of a dam across the lagoon south of the harbor of sufficient height to prevent the escape of the water down the lagoon during the severest northers, and of sufficient compactness to arrest the sediment from the river and keep it from entering the harbor or pass.

A favorable location for this dam would be as shown on the accompanying tracing marked B. This would give it a curved direction, which would facilitate the ingress and egress of the water to and from the lagoon, and also by favoring the flow of the water in a single channel along the face of the dam, the tendency would be to extend the deep water of the pass towards Point Isabel, thus increasing the size of the harbor for deep-draught vessels, and possibly avoid the necessity of lightering altogether. The curvature of this line is almost exactly the same as the course of the channel along the wharf front and to Fort Point, Galveston Harbor, where similar conditions maintain a deep and permanent channel.

In the course of a few years the lagoon south of the dam will have become filled with deposits from the river, into which the dam will be incorporated, making it secure against all future cyclones.

AVAILABLE MATERIAL.

Nothing in the line of lumber or piling can be obtained in this vicinity. Lumber brought from Louisiana and Florida is retailed in Brownsville at $40 per thousand feet, B. M. Freight from Brazos to Brownsville is very expensive, and it is quite probable that lumber in quantities can be delivered at Brazos for $30.

Brush suitable for fascines is not abundant. The great mass of the brush, which grows almost everywhere in the valley, is mesquite and ebony, and both are thorny, but in the vicinity of Tuloso Bayou, on the river, there is willow in sufficient quantities perhaps for the entire work. In case there be not sufficient at this point, at Col. J. G. Tucker's ranch at Santa Maria (90 miles by river above Brownsville), there are about 300 acres of good thornless brush. It is principally hackberry, but there is considerable willow and some ash and elm. It it probable, however, with further search, that plenty of good willow brush can be found along the river within a few miles of Tuloso.

Cane is to be found in limited quantities at different points along the river, and I am assured by Mr. Field, civil engineer, of Brownsville (once connected with the Rio Grande Railroad), that cane is to be found in unlimited quantities only a few miles above Santa Maria on the river.

It is believed, therefore, with a suitable plant for transporting brush from the river through Tuloso Bayou, that it can be delivered at Brazos at a very reasonable price.

Stone it will be difficult and costly to obtain. As far as I could learn, the only stone at all suitable for ballast is to be found near Rio Grande City, about 300 miles by river above Brownsville. This is a fine calcareous sandstone, with a specific gravity of 2.3 and weighs 143 pounds per cubic foot. It can be delivered at Point Isabel for $17.50 per ton. There is a similar stone found near Penitos, about 200 miles from Brownsville, but it is too friable to be of any value as ballast. I obtained a sample of stone from up Laguna Madre, which might possibly be obtained, but if this sample be a fair specimen it is unsuitable for the work. There is one other source from which stone may be obtained in the future, and that is from the Matamoros and Monterey Railroad, which is now being extended towards the latter place, having been purchased recently by Palmer & Sullivan. Its present length is about 7 miles.

No gravel or shell with which to make concrete can be obtained short of 200 miles up the river from Brownsville.

Good bricks, however, can be made very cheaply. They can be had in Brownsville in any quantity for $4 per thousand. If the clay at Point Isabel be found suitable for the purpose, they can be made there at about the same price.

Fuel is very cheap. Good mesquite wood can be had in Brownsville for $3 per cord, and it will cost but little more at Point Isabel. There is this certainty, however, that bricks can be furnished, delivered by rail from Brownsville, at Point Isabel for $7 per thousand, equal to $4 per ton.

If properly burnt and of suitable dimensions, this will furnish an economical material for ballast, nearly, if not quite, as good as any stone that can be obtained.

LABOR.

Unskilled Mexican labor is very abundant and cheap; but white, and especially white skilled labor, is costly. Common Mexican labor in Brownsville is worth 50 cents per day without board, and picked labor 75 cents. At Brazos it will cost a little more, probably 75 cents and board, or about $1 per day.

CONSTRUCTION.

I would therefore respectfully recommend that for the bulk of both the jetties and dam, brush, made into mattresses, and bricks of special form (to be determined by experiment) be used. The dam should have a base of 30 feet and a top width of 15 feet, and a height sufficient to come to the water surface at ordinary high-water. Above this it should have a superstructure consisting of a single row of piles, 4 feet from centers, closely planked on one side to a height of 3 feet with 3-inch plank.

Such a structure will be permanent as regards the brush work and ballast, and the superstructure being out of water except during the northers and extraordinary tides, if kept coal-tarred, will last a great many years and can be renewed when necessary at a small cost. Less costly methods of construction might be adopted, but they all lack the element of permanence which this possesses, and are not enough cheaper to make their construction and renewal economical.

PLANT.

To conduct the work economically quite an extensive plant will be required. In the transportation of brush down Tuloso Bayou it will be necessary to have three light-draught flat-boats and one light-draught steam barge, with sufficient power to stem a 3-mile current in a narrow bayou with a flat in tow. For the construction of the jetties there will be needed two good barges for carrying ballast and sinking mattresses, and one light-draught tow-boat for towing barges and mattresses to the site of the jetties. There will also be needed one steam pile-driver and a cheap wharf and ways for landing brush and making mattresses upon.

ORDER OF PROSECUTION.

The order of prosecuting the work should be, first, the construction of the south jetty; second, the construction of the dam, and, third, the construction of the north jetty.

The south jetty will intercept the drift material brought from the south by the littoral current, causing a building out of the shore line on the south side, and prevent, until this reaches the end of the jetty, any deposition on the bar from this direction. During northers it will confine the water to a single channel across the bar, answering, together with the wind and littoral current from the north, every purpose of two jetties.

The dam will greatly increase the discharge during northers, and if built first would have the effect of pushing the bar further out, and hence increase the cost of the jetties.

The construction of the north jetty will complete the improvement and will insure a permanently good channel during all seasons and stages of tide.

The construction of the dam should not be commenced until there are funds sufficient to complete it, for its partial completion can be of but little benefit, and leaving it so any length of time might very materially increase its final cost.

ESTIMATES.

Detailed estimates of the cost of constructing two jetties across the bar, as proposed by you, have been made. The jetties to be made of brush mattresses, similar to those

used in the improvement of Aransas Pass and Galveston Harbor, ballasted with bricks. Also detailed estimates have been made of the cost of constructing a dam from Point Isabel to Brazos Island, on the line proposed, after three methods. These estimates will be found at the close of this report.

The summary is as follows :

South jetty	$190,901 75
North jetty	129,203 75
Dam	327,979 00
Plant	30,000 00
Total	678,084 50

COMMERCIAL STATISTICS.

Col. J. S. Haynes, collector of the port of Brownsville, has kindly furnished the commercial statistics of the port. From his letter, herewith accompanying, it will be seen that the commerce of Brazos Santiago is of no insignificant importance.

In closing, I desire to express my indebtedness to those citizens of Brownsville and Point Isabel whom I had the pleasure of meeting, for courtesies extended and information freely given. But especially am I indebted to the officers of the Rio Grande Railroad Company and Morgan line, and to Mr. S. W. Brooks, of Brownsville, and Col. J. G. Tucker, of Santa Maria.

ESTIMATED COST OF TWO JETTIES AT BRAZOS SANTIAGO, TEXAS.

South jetty (length 3,630 feet):	
26,339 cubic yards brush-work, at $2.50	$65,847 50
18,000 tons of brick, at $4.50	81,000 00
	146,847 50
Contingencies 30 per cent	44,054 25
Total	190,901 75
North jetty (length 2,940 feet):	
18,155 cubic yards brush-work, at $2.50	45,387 50
12,000 tons of brick, at $4.50	54,000 00
	99,387 50
Contingencies 30 per cent	29,816 25
Total	129,203 75
For both jetties	320,105 50

ESTIMATED COST OF DAM FROM POINT ISABEL TO BRAZOS SANTIAGO.

(To be built of brush mattresses, ballasted with bricks, and with a superstructure of piles and plank.)

Length, 14,000 feet:	
44,000 cubic yards brush work, at $2.50	$110,000
30,140 tons of bricks, at $4.50	135,630
280,000 feet B. M. pine, 8 by 8 inches by 15 feet, at $30	8,400
126,000 feet B. M. pine, 3 by 12 inches, at $30	3,780
34,095 pounds screw bolts, $\frac{3}{8}$ by 12 inches, at 10 cents	3,410
1,260 pounds washers, at 6 cents	76
Labor:	
Driving 3,500 piles, at $2	7,000
Bolting in place 126,000 plank, at 2 cents	2,520
Coal towing (labor and material)	2,500
	273,316
Contingencies 20 per cent	54,663
Total	327,979

ESTIMATED COST OF DAM FROM POINT ISABEL TO BRAZOS SANTIAGO.

(To consist of a row of close piling supported by a second row at intervals of 5 feet.)

Length, 14,000 feet:	
16,800 piles, 12 by 12 inches by 20 feet, at $7.20	$120,960
112,000 feet B. M. pine, 6 by 8 inches, at $30	3,360
52,370 pounds screw bolts, 1 by 20 inches, at 10 cents	5,237
800 pounds washers, at 6 cents	48
Labor:	
Driving 16,800 piles, at $2	33,600
Halving 5,600 piles, at 12½ cents	700
Bolting 112,000 feet waling, at 2 cents	2,240
Creosoting 4,144,000 feet B. M., at 2½ cents	103,600
	269,745
Contingencies 20 per cent	53,949
Total	323,694

ESTIMATED COST OF DAM FROM POINT ISABEL TO BRAZOS SANTIAGO.

(Constructed of two rows of piles, 8 feet apart—piles in rows 5 feet from centers—tied together, and space filled with brush fascines ballasted with bricks.)

Length, 14,000 feet:	
5,600 piles, 10 by 10 inches by 20 feet, at $5	$28,000
59,733 feet B. M. cross-ties, 4 by 8 inches by 8 feet, at $30	1,792
84,000 feet B. M. waling, 3 by 12 inches	2,520
32,870 pounds screw-bolts, ⅞ by 14½ inches, at 10 cents	3,287
27,690 pounds screw-bolts, ⅞ by 15½ inches, at 10 cents	2,769
2,800 washers, at 6 cents	168
7,000 cords brush fascines, at $5	35,000
11,000 tons of brick, in place, at $4.50	49,500
Labor:	
Driving 5,600 piles, at $2	11,200
Bolting 143,733 feet lumber, at 2 cents	2,875
Creosoting 1,077,000 feet B. M., at 2½ cents	26,925
	164,036
Contingencies 20 per cent	32,807
Total	196,843

ESTIMATED COST OF PLANT.

One tow-boat	$12,000
Two barges	5,000
One steam barge	5,000
Three flat-boats	3,000
One steam pile-driver	3,000
Wharf and ways	2,000
Total	30,000

Very respectfully, your obedient servant,

H. C. RIPLEY,
United States Assistant Engineer.

Bvt. Lieut. Col. S. M. MANSFIELD,
Major of Engineers, U. S. A.

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, BROWNSVILLE, TEX.,
Collector's Office, June 14, 1881.

SIR: In reply to your letter of June 8, 1881, requesting to be furnished with commercial statistics of this port for the past year and for five years, in order to show the

importance of Brazos Santiago as a port, I have the honor to inform you that for the past year commencing July 1, 1880, the imports of the district amount to $2,347,778; exports, $2,503,852; aggregating $4,851,630; and for the past 5 years averaging $4,000,000 to $5,000,000 in value per annum.

The above statistics are derived from the records of this office, which do not embrace domestic cargo arriving in vessels of the United States in coasting trade, which amount would augment the given commerce of the port to $8,000,000 or more per annum, very nearly all passing through the port of Brazos Santiago.

Very respectfully,

J. S. HAYNES,
Collector.

H. C. RIPLEY, Esq.,
United States Assistant Engineer.

O 11.

PROTECTION OF RIVER BANK AT FORT BROWN, TEXAS, FROM ENCROACHMENTS OF THE RIO GRANDE.

First appropriation (1876)	$10,000
Second appropriation (1879)	7,000
Total	17,000

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1881.

Certain repairs were found necessary, and during December and January, were put upon the work by hired labor and open purchase. All the damaged mats were thoroughly repaired, and 240 feet of the bank was recovered, which embraced all that portion in front of the Administration building, where some of the mattresses had been switched off by the hurricane of August, 1880.

The old jetty was re-enforced by filling between it and the bank with trees and brush tied fast to the jetty.

Across the pocket in the bank was placed an old cable, wrapped with wire to strengthen it.

To the cable was tied a quantity of trees and brush, which had the effect of checking the up-stream current, and thereby prevented further injuries to the bank, the incline of which is very great.

By aid of the garrison the work received a good coating of earth and grass, materially aiding its finish.

The work seems to have been done satisfactorily, and the operations at this point are supposed to be complete.

Repairs may be needed from time to time, and a small sum should be on hand for immediate use.

Money statement.

July 1, 1880, amount available		$1,295 14
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		1,065 10
July 1, 1881, amount available		230 04
Amount that can be profitably expended in fiscal year ending June 30, 1883		2,000 00

EXTRACT FROM LETTER OF SEPTEMBER 1, 1880, FROM COLONEL OTIS, TWENTY-SECOND INFANTRY, COMMANDING FORT BROWN.

* * * * * * *

I suppose that the water in the river has been higher this year than for many previous seasons, and the rise has been more protracted.

Fifteen feet above low-water mark—and now it is about 12 feet above that level—the bank is intact, and in fact we have fastened in a little soil.

The mattresses worked splendidly until the night of the hurricane, when the high wind, changed to the south, blew the water up the bank clear over on the administration building. It ripped up the mattresses in some places, throwing up the ends of the fascines, but they have settled down again into the mud, or most of them have, and are doing their work well.

The storm washed the mattresses severely, swept away the dirt which had been placed along the bank by Mr. Brooks, and large cracks were opened in some places behind. I then went to work and rebuilt the bank with earth and sod.

We have put on about 1,000 cart-loads of earth, have used a good many sod, and soon we shall present a green front to the people of Mexico.

The work looks now as though it would last for all time. We have made considerable ground in some places, especially in that bend, where we have built out permanently about 8 feet.

I am under the impression that the old vessel, the Rio Bravo, saved us this time. When the rise came, an eddy was created at the termination of the mattress. It washed the bank beyond and behind the same, and was tearing it out. I took the vessel, or rather its hulk, drew it into the hole, and then sunk it, presenting its deck to the current. It formed a perfect jetty, and has deflected the current very much. The sand worked in behind it, and it now lies nearly buried.

All Brownsville rejoiced after the storm, for it was thought that the new Mexican jetties had been completely destroyed. A considerable portion of the upper one washed away, but enough remained to throw the current over onto Brownsville. It is cutting badly into Brownsville now, and is nearly over to the hulk of that old boat.

As I look out now, I see the laborers trying to stop the washing of the bank with willows. Mexico has nothing to complain of this time. She has beaten us on this deal, and had it not been for your mattress, the administration building would have been in the river, and I think the river would have been flowing through the lagoon, for the whole force of that heavy current came for several days almost directly against the bank in our front.

I fear, still, that the river may cut into Brownsville and disturb our entrance. Considerable of the bank has fallen there, and some right at the end of our wall. I have every confidence in the mattress, but I still say that you made a mistake in stopping Brooks, although I know that you had covered all the bank reported on by Captain Livermore.

EXTRACT FROM REPORT OF JUNE 21, 1881, BY MR. H. C. RIPLEY, ASSISTANT ENGINEER.

* * * * * * *

RIVER BANK PROTECTION.

I made an examination of the work for the protection of the river bank at Brownsville, and found that it had been entirely effectual except at one place.

For a distance of about 100 feet extending downstream from the prolongation of the east face of the administration building there has been a settlement of several feet. This settlement was evidently the result of a substratum having been dissolved away, but how this could have been accomplished, with the whole bank protected down to the very bottom of the river, no satisfactory explanation can be given.

Colonel Otis, the commandant of the post, has repaired this portion by covering it with loose brush, held with chains attached to "dead men" back in the bank, and ballasted with iron rubbish from the wreck Rio Bravo.

It is also partially covered with earth.

Aside from this, the bank is in good condition. It is overgrown with grass, and the willows, planted in rows 7 feet apart, are most of them growing nicely.

* * * * * * *

Very respectfully, your obedient servant,

H. C. RIPLEY,
United States Assistant Engineer.

O 12.

SURVEY OF ROUTE FOR A CANAL TO CONNECT GALVESTON WITH THE BRAZOS RIVER, TEXAS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., August 24, 1880.

GENERAL: I have the honor to transmit herewith the report of Assistant Engineer Mr. W. L. Webb upon the survey of the *canal connecting Galveston and Brazos River, Texas*, for which provision was made in the river and harbor act of 1879.

Mr. Webb presents an estimate of the cost of cutting the canal to 6 feet in depth and 100 feet in width as $382,084.28; for cutting the canal 4 feet in depth and 80 feet in width as $70,352.64.

A canal of the latter dimensions will meet all the requirements of commerce in this direction for many years to come.

The present canal will allow of the passage of vessels drawing 3 feet. It was dug and is owned by a private company, and toll is charged for vessels using it.

It is believed that the rights of the company will be relinquished if the government will improve the canal so that it shall have a depth of 6 feet for a width of 80 feet.

Four sheets of tracings accompany the report, to which attention is invited for information bearing upon the character and importance of the work.

It is located in the collection district of Galveston. The nearest lights are in Galveston Bay.

Very respectfully, your obedient servant,
S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut Colonel, U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. W. L. WEBB, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., August 5, 1880.

SIR: I have the honor to submit the following report on the survey of the route for a canal to connect Galveston with the Brazos River.

On March 29, 1880, the party left Galveston, arriving at the Galveston, Houston and Henderson Railroad Bridge, the intial point of the survey, at noon. A tide-gauge was immediately put up, and an hourly record of it was kept during daylight for one month. The survey was commenced the same day, by putting up stations number 1 and number 2; number 1 being on the railroad track near the east end of the bridge.

Beginning at the Galveston, Houston and Henderson Railroad Bridge, the route of the canal is southwesterly through West Bay and Mud Island Pass; thence west, through Follet's Pass; thence southwest, through Christmas Bay and the old Galveston and Brazos Canal, to the Brazos River.

The total distance is 38 miles.

The survey was made by sounding between ranges which were located by a chained azimuth line run down the shore. Whenever the water was deep enough, soundings were taken from the schooner. At first it was proposed to put out two ranges on each cross-section, one on each side the deepest water, the sections being half-a-mile or less apart, and all ranges in adjacent sections were to be connected by lines of soundings. Between the Deer Islands and Caronkaway Reef, and some distance beyond, as it was deemed advisable to extend the examination so as to cover a greater width of the bay, three range-stakes were set in each section, logitudinal lines of soundings being run

from each stake to the corresponding one in the adjacent sections, diagonal lines being also run between the extreme ranges of adjacent sections, except near the Deer Islands and at Caronkaway Reef, where all ranges in adjacent sections were connected by lines of soundings. Near the western end of the bay, where the water is over 6 feet deep at mean low-tide, fewer soundings were taken. The channels running up from San Luis Pass were defined as accurately as practicable.

Through Mud Island Pass, Follett's Pass, and the Brazos Canal one longitudinal line of soundings with occasional sections was taken. Ranges were put up in Christmas Bay and connected by lines of soundings as in West Bay.

Three tide-gauges were established and records of them kept—one at the Galveston, Houston and Henderson Railroad draw-bridge, one at Shell Island, 1½ miles southwest of Caronkaway Reef, and one near the mouth of Follett's Pass. Hourly records of them were kept during daylight. The gauges were not set at any fixed elevation, but the reading of mean low-water for each was determined by comparison of simultaneous readings of high and low tides on each with the gauge at Bolivar Point.

The gauge at Bolivar Point is a self-recording float-gauge on which the elevation of mean low-tide has been determined from observations extending over a period of several years. The following are the results of these comparisons:

For the gauge at Galveston, Houston and Henderson Railroad draw-bridge:

	Feet.
Reading of mean low-tide from observations at high-tide	2.511
Reading of mean low-tide from observations at low-tide	2.664
Mean	2.587

For the gauge at Follett's Pass:

Reading of mean low-tide from observations at high-tide	1.400
Reading of mean low-tide from observations at low-tide	1.380
Mean	1.390

For the gauge at Shell Island, from comparison with the Follett's Pass guage:

Reading of mean low-tide from observations at high-tides	0.855

(No comparison at low-tide).

From comparison with the Galveston, Houston and Henderson Railroad bridge gauge:

Reading of mean low-tide from observations at high-tide	0.779
Reading of mean low-tide from observations at low-tide	0.800
Mean	0.7895
Mean of readings at draw-bridge and Follett's Pass	0.822

The extreme rise and fall of the tide is about 2 feet, the average being 1 foot.

The tides of West Bay come in through the entrance to Galveston Harbor at the northeast end of Galveston Island and through San Luis Pass at the southwest end of the Island. If they are not influenced by the wind, they meet at Caronkaway Reef, and may thus account for the formation of the reef.

The reef is composed entirely of oyster-shells. The reef is 13 miles distant by route of the tide from San Luis Pass Bar and 22 miles from the Galveston Entrance Bar. High-tides and low-tides occur at about the same time at the Galveston, Houston and Henderson draw-bridge and at San Luis Pass.

The velocity of the tide from San Luis Pass is found to be about 5 miles per hour, while that from the draw-bridge, having to pass through the narrow channels between the Deer Islands and over shoal-water, has a velocity of only 3.75 miles per hour.

This seems to indicate that the tidal wave of the Gulf of Mexico reaches the Galveston Entrance earlier than San Luis Pass by a time sufficient to allow that part of it entering the Galveston Channel to travel to the railroad draw-bridge, a distance of 13 miles. I have been unable to determine this time, as there is no gauge on the bar at Galveston. I have been told by seamen well acquainted with this coast that there is almost always a current flowing to the southwest along the Gulf shore of Galveston Island during flood-tide. During a calm it has been estimated at 3 miles per hour.

GENERAL DESCRIPTION OF THE ROUTE.

The canal will run for 22 miles through West Bay, thence through Mud Island Pass, Follett's Pass, Christmas Bay, and the old Galveston and Brazos Canal, to the Brazos River. West Bay is from 2½ to 3 miles wide and 3 to 7 feet deep, with occasional shoal reefs, and nearer the southwest end deeper channels making up from San Luis Pass.

The bottom is principally mud and shells mixed, quicksand being found near San Luis Pass. Mud Island Pass is a narrow channel between Mud Island and San Luis

Island, 5,000 feet long, 250 to 300 feet wide, and 3½ to 7 feet deep. The bottom is very soft mud. Follett's Pass, connecting Christmas Bay with the Gulf of Mexico, is from 700 to 1,000 feet wide and 8 to 18 feet deep; 9,000 feet of it will be traveled by boats using the canal. Through Christmas Bay to the northeast end of the old canal the course will be partly through a cut made in 1851, and for 14,700 feet through water 2½ to 3½ feet deep. The bottom is soft, with a few shells at places. The old canal is nearly 8 miles long. It was first dug in 1850–'51, and was again cleared out in 1866–'67. Its dimensions were 100 feet wide by 6 feet deep. Now it averages about 80 feet wide and from 2½ to 9 feet deep, the usual depth being about 3½ feet.

The bottom feels soft, a pole being easily pushed down several feet; but the banks already thrown up show more or less shells. The material excavated was thrown up on each side, and when its course lay overland consisted principally of blue clay, which stands in the banks at a slope of 1 to 1. It runs for 4 miles through Shallow Bay and bayous, the balance of the distance being overland from 2 to 5 feet above mean low-tide. In the bays great difficulty was experienced in getting the material to lie in bank, as the soft mud, through containing more or less shells, was semi-fluid when disturbed by the dredge. Finally a revetment of posts and planking was made on each side the canal, behind which the material excavated was thrown.

The canal was dug and is still owned by a private company, and toll is paid by vessels using it; but I am assured by a number of stockholders that if a channel 6 feet deep by 80 feet wide is made from Galveston to the Brazos River they will relinquish their right to the canal.

At the time the canal was made funds appropriated by the State of Texas were expended in dredging a channel in Christmas Bay, near the entrance to Follett's Pass, through Mud Island Pass, and in West Bay at the Caronkaway Reef, and between the Little and South Deer Islands. The cut in Christmas Bay has been dredged several times since and is still open. Mud Island Pass has shoaled considerably near the southern end. Only a slight trace of the cut is found at Caronkaway Reef, while at the Deer Islands there has been less shoaling, the material of the bottom there consisting largely of shells.

THE COUNTRY TO BE BENEFITED BY THE CANAL.

The country on each side the canal and for some distance north is generally low and swampy and only occasional tracts are cultivated, they lying on the Gulf shore. The canal runs through Galveston and Brazoria counties.

The country to be benefited by the canal lies on each side the Brazos River, in the counties of Brazoria, Fort Bend, Wharton, and Matagorda. These four counties, from their exceeding fertility, are called the "Four Counties" or the "Sugar Bowl" of Texas. The chief productions of the country are sugar and cotton, though corn, wheat, rye, barley, oats, millet, tobacco, Irish and sweet potatoes, and vegetables of all kinds are successfully raised. Attention is chiefly paid to the cultivation of cotton and sugar, and extensive improvements have been made on the plantations to that end. The land is owned in large tracts, is well drained, and large sugar-houses and cotton-gins have been erected. I have been unable to get statistics of the exports as they are taken off by three railroads, and in steamers and schooners.

They go principally to Galveston, Houston, and Indianola. The Brazos River is navigable at all seasons of the year, for vessels drawing 6 feet, from its mouth to 10 miles above Columbia, a distance of 102 miles. The San Bernard River, a few miles west of the Brazos, is navigable for about the same distance.

The country west of the Brazos is low and marshy, traversed by numerous bayous, which, with comparatively slight dredging, would afford inland navigation from Galveston into Matagorda Bay, and would give transportation facilities to the most productive part of the State of Texas. An estimate of cost has been made for such a canal (see Report of Chief of Engineers for 1875, part I, page 901.)

ESTIMATES.

The estimate of cost of the canal includes dredging, the marking of the dredged channel by range piles, and where the bottom is very soft, as in Mud Island Pass and Christmas Bay, a wooden revetment will be needed on each side to prevent the dredged material from returning into the channel. For a greater part of the distance the material can be run off to each side through shoots to prevent its returning into the channel.

The piles should be covered with zinc from the bottom to above high-tide.

They will be placed at intervals of 2,000 feet on straight portions of the canal, and 400 feet apart on curves. The revetment should be 3 feet high, made of 2-inch plank laid on edge, supported at intervals of 10 feet by 6 by 4 inch posts; 8 feet, board measure, per running foot, is estimated for it. The following is the estimate for a channel 6 feet deep by 100 feet wide:

DREDGING.

West Bay:

	Cu. yds.	Cu. yds.
Sand	5,300	
Shells	18,285	
Mud and shells	390,241	
		413,826
Mud Island Pass (very soft mud)		38,148
Christmas Bay (very soft mud)		148,368
The old canal (very soft mud)		436,556

Total, 1,036,898 cubic yards, at 30 cents	$311,069 40
150 range piles, at $5	750 00
Wooden revetment, 325 M feet, B. M., lumber, at $20 per M	6,500 00
1,700 pounds nails, at 5 cents	85 00
Total	318,404 40
Add 20 per cent. for contingencies	63,680 88
Grand total	382,084 28

As the old canal is now only 80 feet wide, it is not deemed advisable to increase its width.

The estimate for dredging has been made for a channel 100 feet wide from the railroad draw-bridge to the canal, and 80 feet wide through the canal.

Although it is very desirable to have a channel 6 feet deep by 100 feet wide, one 4 feet by 80 feet will be sufficient for boats now using this route. The following estimate is made for such a channel:

THROUGH THE BAYS FROM THE DRAW-BRIDGE TO THE MOUTH OF THE CANAL.

	Cubic yards.
Dredging:	
West Bay:	
Mud and shells	32,651
Shells	16,696
Mud Island Pass—soft mud	2,963
Christmas Bay—soft mud	34,918
Total	87,228

At 30 cents per cubic yard	$26,168 40
27 range piles, at $5	135 00
Wooden revetment—138 M feet, B. M., lumber, at $20 per M	2,760 00
1,200 pounds nails, at 5 cents	60 00
Total	29,123 40
Add 20 per cent. for contingencies	5,824 68
Total	34,948 08

FOR THE CANAL.

Dredging:	
Soft mud—95,496 cubic yards, at 30 cents	$28,648 80
Wood revetment—42 M feet, B. M., lumber, at $20 per M	840 00
300 pounds of nails, at 5 cents	15 00
Total	29,503 80
Add 20 per cent. for contingencies	5,900 76
	35,404 56
Estimate, from draw-bridge to mouth of canal	34,948 08
Grand total	70,352 64

The estimates for the cuts through the bays and through the canal are given separately, as I do not know if the owners of the canal will relinquish their right to it if it is only deepened to 4 feet.

Respectfully,

W. L. WEBB,
Assistant Engineer.

Col. S. M. MANSFIELD,
Major Corps of Engineers.

APPENDIX P.

PRESERVATION OF THE PORTS OF MEMPHIS, VICKSBURG, AND NATCHEZ; IMPROVEMENT OF THE MOUTH OF RED RIVER; OF THE RAFT IN UPPER RED RIVER, LOUISIANA AND ARKANSAS; OF CERTAIN RIVERS IN MISSISSIPPI AND TENNESSEE; WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

REPORT OF MAJOR W. H. H. BENYAURD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 27, 1881.

GENERAL: I have the honor to transmit herewith annual reports upon the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER AND HARBOR AT MEMPHIS, TENNESSEE.

Early in August last, the water having become low enough, work was recommenced upon the bank revetment and continued down stream until a junction was effected with the stone landing put in by the city authorities. The total distance along the stretch of the river protected this season was 1,150 feet. An examination recently made shows that there has been no caving along the front, and that the work thus far has done all that was expected of it in preventing the caving away of the city front. So much confidence has been placed in the work, that parties and corporations have, and are making arrangements now, for the construction of buildings and elevators on the bank, that a couple of years ago looked as if it was certain to go into the river. The cost of construction of these improvements amounts to upwards of $500,000.

For the protection of the bank above the mouth of the Wolf River, two lines of screens of different designs were put in, the bank having first been protected to prevent the river washing around that end; four of these

screens were made of wood and twelve of cane. An examination of the bank shows that the screens prevented the caving of the bank where they were placed, and in addition caused a deposit of sand to an average depth of not less than 8 feet. The screens were exposed during the winter and high-water stage to running drift and ice, and upon the subsidence of the water the wooden ones were found perfectly intact, while the cane ones were bent over and borne to the bottom under an accumulation of sand. They have, however, subserved the purpose for which they were intended.

During the coming season it is proposed to extend the protection work of the bank above the mouth of Wolf River as far as the funds will permit, using mattresses and screen work.

An examination also will be made of the river above, to see what changes are in progress that will be likely to affect the harbor of Memphis. The appropriation asked for for the fiscal year ending June 30, 1883, will be expended as heretofore.

For the details of the operations I beg leave to refer to the report of of Mr. Joseph Burney, assistant engineer, herewith.

The total estimated cost of this improvement was $170,000.

The former appropriations are as follows:

By act approved June 18, 1878	$46,000
By act approved March 3, 1879	37,000
By act approved June 14, 1880	15,000
By act approved March 3, 1881	15,000

Money statement.

July 1, 1880, amount available	$31,501 84	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$46,501 84
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		30,411 30
July 1, 1881, amount available		16,090 54
Amount (estimated) required for completion of existing project		57,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		57,000 00

REPORT OF MR. JOSEPH BURNEY, ASSISTANT ENGINEER.

MEMPHIS, TENN., *June* 30, 1881.

MAJOR: I have the honor to submit my annual report of operations of work done on the Memphis River front for the year ending June 30, 1881.

During the low-water of 1880 a careful examination of the bank protected was made, and it was found to be all in good condition; no caving had taken place. Before being protected, the bank caved back at the rate of 100 feet per year.

Active operations were again commenced August 2, 1880; the work consisted of the construction and sinking of mattresses, commencing at the bank where we suspended operations last season, and continued from the foot of Poplar street to the foot of Jefferson street, where the mattress protection joins the public paved wharf of Memphis.

The distance protected the present season is 1,150 feet. For this we constructed and sunk 23 mattresses, each 125 by 60 by 2.5 feet. In their construction were used 2,432 cords of willow brush and 314 cords of cottonwood poles. In sinking the mattresses 880 cubic yards of stone was used, and in grading the upper bank 2,679 cubic yards of earth were removed, and in securing the mattresses to the bank, 38 piles were driven through the upper end of them and cut off even with the top. We had gained considerable experience during the past two seasons' work, and this was the first season we had been able to work during low-water. We met with not a single accident, all the mattresses were sunk in a workman-like manner, and we did not lose a single mattress nor any portion of one.

We constructed a wood portable tramway 3,000 feet long, and built 4 cars for obtaining willow brush, and we made a considerable saving in the cost of mattresses by building our mattress-ways near the tramway, thus saving the loading the willows into boats and out of them again and then towing the empty barges back to the willow camp.

	Ft. of bank.
In 1878–'9 we protected	675
1879–'80 we protected——	1,300
1880–'81 we protected	1,150
Total bank protected	3,125

December 2, 1880, we had the lowest water of the season, the reading on the gauge being 2.7 feet. A careful examination of the bank protected was made and was found to be in good order. No caving had taken place, except in front of Messrs. Brown & Jones's coal-yard, where the upper bank had caved for 150 feet long and 20 feet back, and had pushed the mattress in front into the river. At the time this portion of the front was protected it was a very busy season with the coal merchants, who had their coal fleet secured in front of the bank, so that we could only get access to it for a few hours to sink our mattresses, and were not allowed sufficient time to secure them with piles as we had the others, nor were we able to grade back the upper bank, for carts were constantly passing over it, delivering coal from the coal-flats.

In my last year's report I drew attention to the bank a short distance below the bank protected, on which was located the Memphis and Paducah freight depot. The railroad company expended over $7,000 in driving piles for its protection, but failed to keep the bank from caving, and the depot buildings had to be removed to another location. On arriving at this portion of the bank we removed 28 piles which were in the way of the mattresses, and since they have been sunk the bank has not caved a single foot.

With the exception of the cave in front of Brown & Jones's coal-yard, and a slight cave at the mouth of Wolf River reported in my last annual report the work has proved very successful. Had it not been for the protection afforded by the mattresses over 300 feet of bank containing many valuable buildings would have been lost, and no improvements would have been made, while now so much confidence has been gained that over $500,000 of improvements have been made and are now in course of construction.

The work from the mouth of Wolf River to the foot of Jefferson street was suspended October 28, 1880, and no work has been done on that part of the front since that date.

In November you made an examination of the work, and gave instructions to commence work on the bank above Wolf River. This bank had been caving fast; in three years it had caved back 300 feet, and was endangering our work below.

Instead of protecting the bank by mattresses, your instructions were to protect it by floating screens, to be made of various designs and material, so as to find out the kind best adapted for the purpose.

The site selected by you was on a sand-bar immediately above the caving bank, and located below Tennessee chute and above Frame's Chute. Accordingly the quarter-boat and outfit were moved up to this point, and work commenced November 2, 1880. As the work was of an experimental nature, and in accordance with your instructions, the working force was greatly reduced, and the tug-boat Clarence, which was chartered for the work, was discharged.

The first part of the work was to secure the sand-bar from scouring; this was done by constructing on the bar a mattress 250 by 60 by 2.5 feet; this was ballasted with rock and covered over with sand, and extended from the top of the bank to the water's edge. We then constructed two mattresses on the ways, each 100 by 60 by 2.5 feet, secured them together and floated them down in front of the shore protection, and sunk them lengthways across the river. A third mattress was constructed on the ways 100 by 60 by 2.6 feet, and sunk one-half on the shore protection, the water having risen sufficiently for this being done, and the other half on the 200 feet of mattress sunk in the river; the whole of the mattress work was then secured together, thus forming one continuous mattress 450 by 60 by 2.5 feet, and making a good protection for the sand-bar, upon which the river was rapidly encroaching.

Upon this mattress foundation ten screens of various designs and sizes were secured. The method of securing those on the bank was as follows: We sunk into the bank a log 4 feet deep, on which was bolted an upright post 12 inches in diameter, and projecting above the bar 4 feet. Each screen had two posts, to which they were secured by ¾-inch chain. For securing the screens in the water we constructed crib-work made of cottonwood poles. The size of crib was 16 by 4 by 4 feet. We loaded the crib with stone, and after securing the screens to them with 2¾-inch chains, let the crib and screen into position with our steam pile-driver.

A second line of screens was commenced about 600 feet below the first, and imme-

diately below Frame's Chute; four screens were sunk, when the river commenced rising, and work was suspended on account of high water.

Under your direction a careful survey was made above and below the line of screens before the work was commenced, and as soon as the water falls sufficiently another survey will be made, so as to find the result caused by the screens. At this date the water is too high to report results.

In February, 1881, work was entirely suspended, the outfit, tools, &c. stored away, and the boats, pile-driver, &c., placed in Wolf River and left in charge of two watchmen.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Merchandise and produce sold for twelve months ending June 30, 1881, $73,200,000. Of this amount $23,750,000 was cotton; home produce, and home manufacture, $3,400,000.

Amount of cotton received from September 1, 1880, to June 30, 1881, 460,771 bales.

Wharfage tax to steamboats, charged by the city for the year ending June 30, 1881 $22,877.

The collections at custom-house in Memphis, Tenn., during the year ending June 30, 1881, are as follows:

Duties on imports	$15,232 77
Hospital dues (marine)	1,522 29
Steamboat inspection	2,297 85
Licenses to engineers, pilots, &c	3,725 00
Fines, penalties, &c	100,00
Total	22,877 91

P 2.

IMPROVEMENT OF THE MISSISSIPPI RIVER AND HARBOR AT VICKSBURG, MISSISSIPPI.

With the comparatively small appropriation, work was continued at the Delta Point for the purpose of holding this important bank, and in protecting the work hitherto accomplished.

An examination, lately made, of the locality shows that the work is holding well notwithstanding the continued action of high-water during the very long season. The lower end not being fully protected was of course subjected to the action of the river, and a portion caved away, but this will be remedied in the course of the present season's work.

Had the appropriation asked for last year been made it was intended to apply a portion to the work at Delta Point and the remainder to dredging out the inner harbor, but the amount given being insufficient to accomplish any great results on this latter work it is intended to apply the whole amount to the Delta Point work. This being held, there is no doubt we can make a steamboat channel to the elevator landing at Vicksburg by dredging. This is in accordance with the recommendation of the Board of Engineers. I do not look to any means to throw the channel of the Mississippi River around and back again in its former channel within ordinary limits of expense.

A survey recently made by Mr. T. G. Dabney, assistant engineer, shows that there has been no perceptible filling up of the inner harbor for the past two seasons. A channel can therefore be dredged from the

lower limits of the fill to the elevator. Estimates for this work were presented in the annual report for last year, and the sum of $150,000 asked for to be applied to this object.

If this be accomplished, the authorities of Vicksburg state that they will maintain the channel open with their own means.

The former appropriations are as follows:

By act approved June 18, 1878	$84,000
By act approved March 3, 1879	50,000
By act approved June 14, 1880	20,000
By act approved March 3, 1881	75,000

For the details of the operations I beg leave to refer to the report of Mr. T. G. Dabney, assistant engineer, herewith.

Money statement.

July 1, 1880, amount available	$20,787 18	
Amount appropriated by act approved March 3, 1881	75,000 00	
		$95,787 18
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		21,140 23
July 1, 1881, amount available		74,646 95
Amount that can be profitably expended in fiscal year ending June 30, 1883.		200,000 00

REPORT OF MR. T. G. DABNEY, ASSISTANT ENGINEER.

VICKSBURG, MISS., *June* 30, 1881.

MAJOR: I have the honor to submit the following report of the work in my charge for improving the harbor and Mississippi River, at Vicksburg, Miss.

The appropriation for this work for last season was comparatively very small, and was consumed in repairing the damage sustained by the work previously accomplished, from the high-water of last year, and in carrying the revetment on the most exposed portion of the work to the top of the bank. The judicious application of this fund ($20,000) is evidenced by the present excellent condition of the portion of the bank upon which it was expended, which remains intact, notwithstanding the violent action of the current upon it during the high-water of this spring.

The only portion which has suffered damage is the lower extremity, which, being entirely unprotected from below, was attacked by the formation of an eddy, which, working out a deep pocket just below the revetment, carried away about 200 feet from the lower end.

It is urgently necessary that some work be done this season to secure the lower end of this revetment, even if it should be determined not to carry it on to completion during this year. The upper extremity of this part of the work is also threatened for want of flank protection, which ought not to be neglected this season. I may here be permitted to observe that an error was committed in the prosecution of this work previous to last season, which I believe was generally the case in similar works elsewhere, that is, in ignoring the upper bank protection, as it was deemed only necessary to cover the slope from low-water line to the bottom. Experience here, as elsewhere, has shown that it is highly important to protect well the bank, even to the top, and to this end it is desirable that some expeditious and effective method should be devised for grading the upper bank to a proper slope to receive the revetment. This has been successfully accomplished on the Missouri River by the use of a powerful steam-pump, which, throwing a jet of water against the face of the bank, rapidly cuts it away to any desired slope. I am also strongly impressed with the advantage of making the protection on the lower slope a continuous and homogeneous revetment, instead of sinking detached mattresses. It is a matter of some doubt as to whether such application is practicable under the conditions which obtain in the vicinity of Vicksburg and Natchez. I would recommend, however, that the experiment be made, though some special plant will be necessary.

The record of work done in the improvement of the Vicksburg Harbor during the low-water season of 1880–'81 is as follows:

There were constructed and properly sunk 8 willow mattresses, each 125 by 50 feet; 1 100 by 50 feet; 2 35 by 50 feet; and 1 63 by 40 feet.

The upper bank protection consisted in grading and revetting the bank for a linear extent of about 1,000 feet, the surface thus treated aggregating 52,590 superficial feet. This revetment was composed of willow facines, laid on to a thickness of about 8 inches, secured by transverse poles, which were fastened by wire attached to "dead-men" underneath. This application has proved quite effective, and it is gratifying to notice that the willows are generally growing.

In addition to the above work, there was constructed a short spur dike, on a nearly horizontal "shelf," created by the erosive action of the current above and behind the lower revetment. This dike extends from near the top of the bank to the upper edge of the lower revetment, having a length of 85 feet, width 32 feet, and height of 13½ feet at the outer end. It consists of willows laid down and secured by rock ballast and transverse poles wired to "dead-men" underneath.

The dike has behaved very well during the high-water period, having caused a deposit immediately below it up to the top of the dike itself. The willows composing it are also growing.

The river has not yet reached a suitable stage for making general examinations to determine what changes have occurred since last year. A partial examination discloses the fact that the conditions are very favorable for the execution of the plan already recommended for excavating a basin and canal in front of the town, as no appreciable addition to the former deposit has been detected in the harbor. The more active influences are now operating outside of the harbor, and the extensive deposition of matter will be in localities not involved in the work contemplated.

It is to be regretted that the appropriation for this season is insufficient to advance the dredge work very far towards completion, and that it was not made available early enough to have everything in readiness for active operations as soon as the stage of water would admit.

Very respectfully, your obedient servant,

T. G. DABNEY,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The total amount of cotton shipped from the port of Vicksburg during the year ending September 1, 1880, was 141,561 bales. Of this amount 47,187 bales were handled by the Compress alone.

In addition to this there was shipped from Delta in the same period 49,594 bales, which were brought in by rail, besides some local shipments.

All the steamboats passing too and from New Orleans to points further north land at this place, and are more or less affected by the improvement of the harbor.

The estimated value of the commerce of Vicksburg outside of the cotton receipts is between $7,000,000 and $8,000,000.

P 3.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

This work was commenced last season with an appropriation of $40,000, made by act of June 14, 1880. The total estimated cost of the work was $939,600.

With this comparatively small amount it was difficult to determine where, in the long stretch of river that demanded attention, it would be best to expend the money with the view of securing the best results. As the river threatened to break into Lake Concordia at two points, and as the hard clay point at Good Hope Landing near the upper end of the lake afforded the best protection for the head of the proposed work, operations were started at that point and continued down stream.

Twenty-three mattresses and three screens were sunk, and at last accounts were holding well.

The river broke into the lake at the lower end in the course of the

season, and as had been anticipated no great disturbance in the condition took place. The State Board of Engineers, late in the season, built a levee extending entirely around the lake and joining the levee on the Mississippi River at Rifle Point.

An examination made this month, of the river from Rifle Point to Vidalia shows that the caving still continues with great rapidity in Giles's Bend, Marengo Bend, and Cowper Bend, as hitherto reported, and which ultimately must have its effects upon the harbors of Natchez and Vidalia. It is probable that since the close of the last season's work the bank on the upper end of the neck has caved away some 400 feet, while the caving in Marengo Bend has averaged from 600 to 800 feet. Viewing the situation as it is, and desiring to obtain the greatest amount of good with the means at hand, I think it desirable to proceed with the work of protecting Giles's Bend as indicated in the original report. At the rate the caving is proceeding with at present, I think better results can be obtained, looking to the protection of the harbors of Natchez and Vidalia, by this work than at operating in Marengo Bend. Were the appropriations sufficient to operate in both bends, work could be carried on to that intent, but the present appropriation will not admit of extensive operations.

Sufficient funds should be appropriated to effect the objects in view at the earliest possible moment, otherwise greater expense is entailed each year, and work completed one year is likely to be destroyed before operations can be commenced again the following year under the new appropriation.

In work such as is intended at various points on the lower river, a plant is required which cannot help but be expensive, owing to the difficult nature of the work and the various elements we have to contend with. Such a plant as would be required at Vicksburg or Natchez for work must, therefore, necessarily absorb a considerable portion of the amounts appropriated, and as in the case of Natchez, the plant, such as had to be obtained from the first appropriation, would have sufficed probably for a sum four times as great, but this does not seem to be taken into consideration when the appropriations are made. To obtain any definite and decisive results, the appropriations should be made commensurate with the importance of the results desired to be obtained.

With the appropriation asked for for the fiscal year ending June 30, 1883, the revetment and protection of the caving bends will be carried on.

For the details of the operations I beg leave to refer to the report of Mr. T. G. Dabney, assistant engineer, herewith.

The former appropriations are as follows:

By act approved June 14, 1880	$40,000 00
By act approved March 3, 1881	50,000 00

Money statement.

July 1, 1880, amount available	$40,000 00	
Amount appropriated by act approved March 3, 1881	50,000 00	
		$90,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		40,147 22
July 1, 1881, amount available		49,852 78
Amount (estimated) required for completion of existing project		849,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		150,000 00

REPORT OF MR. T. G. DABNEY, ASSISTANT ENGINEER.

VICKSBURG, MISS., *June* 30, 1881.

MAJOR: I have the honor to submit the following report of the work in my charge for improving the Mississippi River at Natchez and Vidalia.

I was placed by you in charge of this work about the beginning of the working season last year, with instructions to commence at the mouth of Bullitt's Bayou, at the head of Marengo Bend, on the Louisiana shore, and proceed down the stream with the work of revetting the bank with willow mattresses.

The whole work contemplated in this locality was the protection by revetment of about 8¾ miles of badly caving bank, a little more than 6 miles being on the Louisiana side, and a little less than 2¾ miles on the Mississippi side, the estimated cost being nearly $900,000.

The appropriation for last season's operations amounted to $40,000. Even with the most rigid economy it was necessary to expend a large part of the appropriation in preparations for the work, and comparatively little was available for making actual progress.

The record of actual work done in this locality is as follows:

There were constructed and sunk twenty-three willow mattresses, each being 140 by 50 feet and 20 inches thick, composed of willows between frames of poles, well wired together. Five of these were sunk above the mouth of Bullitt's Bayou, and eighteen below.

In addition to the mattresses there were made and sunk three "screens" or "curtains," composed of willows and wire, each 150 by 35 feet. They were well anchored on the lower edge, with gunny-bags filled with stone and gravel, and buoyed on the upper edge with oil casks. These screens were applied as a matter of experiment, being located on the revetment and extending down the slope below low-water line.

There has been no opportunity since to ascertain their effect. A large portion of the bank in this locality intended to be treated with the revetment is heavily timbered, and the trees as they caved in the river were anchored down by the masses of earth adhering to the roots, so as to occupy the whole slope and preclude entirely the application of any sort of protection work. As the only means of combating this difficulty, I cleared the bank of timber for nearly 2 miles in linear extent along the Louisiana shore to a width of 400 feet, in order that as the caving progressed it would leave a clear slope to operate on. The cost of clearing was $1,770, or $20 per acre, but most of it was the lightest character of timber that prevails on this bank. That is to say, it was comparatively small, but exceedingly thick.

One immediate evil which was threatened by the caving of the bank in Marengo Bend was the destruction of the front levee, an expensive embankment, some 7 or 8 miles long, between Lake Concordia and the river. The weak point was near the lower extremity of the bend, between 5 and 6 miles from where it was necessary to begin the work of protection. It is obvious that any effort to afford relief prompt enough to prevent this catastrophe with an appropriation of $40,000 would be futile. As a matter of fact, the evil was precipitated before the work could be got fairly under way by the river coming through the levee and into the lower end of Lake Concordia, thus leaving no ground upon which to erect another levee between the lake and the river. This trouble was foreseen, however, and a remedy applied by the Louisiana State Board of Engineers, who caused to be built a new levee outside of and along the west bank of the lake, connecting above and below with the river system of levees. The mere fact of the river having caved into the lake has no particular significance, as the bed of the lake at that point is fully 30 feet above low-water level, and the formation very tenacious, so that no acceleration in the rate of caving will result.

The expanse of ground which still remains between the river bank and the rear lots of the town of Vidalia, opposite Natchez, is something over 10,000 feet. This ground must all be absorbed by the river before any serious evil can result to the harbor of Natchez from this caving, so that the danger from this source is comparatively remote, as at least twenty years must elapse before this destruction is accomplished. The event, however, seems inevitable in time, unless arrested by a proper remedy.

There is another and more immediate danger, by which the existence of the Natchez Harbor is imperiled.

That is the certainty of a cut-off occurring across the peninsula above Natchez from the rapid caving in of Cowpen (or Giles's) Bend. This catastrophe, if not prevented, will be consummated in probably less than half the time that must be consumed by the influences that are operating to the same end on the opposite side of the river. This bank therefore calls for more immediate attention. Another consideration in this connection is that the amount of work necessary to accomplish the desired object on this side of the river is much less than is necessary on the Louisiana side, and the small inadequate yearly appropriations can here be applied with much better comparative effect.

I cannot help here adverting to the wretched system of economy pursued in the

appropriations made by Congress for specific works, in which the opinions and estimates of engineers are entirely ignored, the sums appropriated being purely arbitrary, and, from their insufficiency to accomplish the work in view, the result is frequently large waste of money and but little good accomplished.

I would strongly recommend that the experiment be made of applying a *continuous* revetment, as distinguished from detached mattresses, along the caving bank in Cowpen Bend, and that the bank be graded and protective work applied up to the top surface.

Very respectfully, your obedient servant,

T. G. DABNEY,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF NATCHEZ, MISSISSIPPI, FOR THE YEAR ENDING JUNE 30, 1881.

Bales of cotton received and shipped by steamboat, 29,000. Sales of merchandise, &c., $1,750,000. Number of landings made by steamboats at wharf, 1,040.

The city has two new cotton mills, one of which has a capital of $250,000 and employs 300 laborers, and the other has a capital of $150,000 and employs 100 laborers.

At present the city is entirely dependent upon the river for obtaining supplies and for shipping its exports. It has no connection with any outside railroad, but a new railroad (narrow guage) is being constructed from Natchez to Jackson, Miss., which is expected to be completed by the 1st of January, 1882.

Vidalia, La., immediately opposite Natchez, contains 600 inhabitants and ships 8,000 bales of cotton.

The port of entry is New Orleans, La.

P 4.

IMPROVEMENT OF MOUTH OF RED RIVER, LOUISIANA.

For the purpose of keeping the channel of Old River open, the dredge-boat Lone Star, in charge of Capt. M. B. Lydon, was stationed on the outer bar at the mouth, and two tugs and a steamer were employed on the inner bar, between the Gut and the Atchafalaya. In the operations the dredge-boat removed 38,574 cubic yards of material.

The work of the steamer and tugs was similar to that of previous years; that is, running backwards and forwards through the obstruction, stirring up the soft material and inducing a current to carry the same off. From five to ten trips were made daily, until towards the close of the season, when it only became necessary to make a couple of trips each day.

By the combined efforts of the plant, navigation was kept open during the entire low-water season. A few cases of detention were reported, but there would have been none such if the captains of the steamboats navigating the river had given a little more consideration to the endeavors made by us to give them a good navigable channel. For the details of this latter work I refer to the report of Captain Flood, herewith.

For the purpose of carrying out the recommendations of the Board of Engineers for Fortifications and for River and Harbor Improvements, &c., "that observations and measurements should be made in order to determine the change taking place in the Atchafalaya and Old River," I sent a party, in charge of Mr. W. M. Rees, to Old River, with the necessary instructions for carrying on the work. The report of Mr. Rees, herewith, gives in detail the extent of the operations. The results show

that Old River continues to fill and the Atchafalaya to enlarge, and that dredging operations, therefore, as the means of keeping a navigable channel will become more serious each year.

Under orders from the department the survey of Bayou Cut-off as an avenue of communication between the Red and the Mississippi will be made in the course of the summer, and the result and report thereon will be submitted in time for the action of Congress.

During the coming low-water season it is proposed to continue operations on the temporary improvement by keeping the channel open by the dredge and similar means as heretofore used. The sounding and cross-section party will also run over the lines of last year for the purpose of making comparisons with the former surveys, in order to determine what changes have taken place in the course of the year in the Atchafalaya and Old River.

The former appropriations are as follows:

By act approved June 18, 1878	$150,000
By act approved March 3, 1879	40,000

Money statement.

July 1, 1880, amount available	$160,880 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	34,675 36
July 1, 1881, amount available	126,204 64

REPORT OF MR. ED. FLOOD, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *December* 20, 1880.

MAJOR: I have the honor to submit the following report of operations in Old River, Louisiana, during the low-water season of 1880:

Acting under instructions from you, dated Memphis, August 5, 1880, I notified Mr. Fagan of the acceptance of his proposition to furnish fleet, and had everything ready to leave next day, but being unable to get a crew did not get off until the 8th, when I left with the steamer Saint Mary and tugs Allison and Wright (two of the most powerful tugs that could be procured). Being delayed on the way by fog and bad weather, we did not reach the mouth of Red River until the 11th.

I immediately went to work and succeeded in getting the tugs in through Lydon's Chute the next day, and commenced operations in the Gut or "Mud Hole" at once, working the boats lashed together.

Up to September 1 the boats made from five to ten trips daily; after that time, the water having fallen considerably, they only made three to five trips and sometimes only two trips daily.

On September 4 the steamer Saint Mary broke down and was returned to New Orleans, and the steamer Painter No. 2 arrived on the 9th to replace her.

My work up to this time had been confined between the foot of the island and lower end of crossing, but as the river commenced to rise and the current changed towards the Atchafalaya, I changed my operations, and worked on the crossing towards Barbre's; for the two weeks ending October 16, my operations were again changed to space between foot of island and Ash Cabin, principally on mud lumps just above foot of island; from that time until suspension (the dredge having worked on mud lumps) I confined my operations from lower end of crossing to Barbre's.

The only actual trouble that boats had during time fleet was there was during week ending October 30, when the Salvor No. 2, a double hull wrecking-boat, came broadside against us and completely blocked the channel for forty-eight hours; in the same week the steamers Wm. Fagan and Alexandria lost several hours between crossing and Barbre's, because they tried to tow heavily loaded barges when the channel was not wide enough to admit them.

In the week ending November 6 the river commenced rising and the current changed towards the Mississippi River, and on November 10, the river having risen about 4 feet, leaving a depth of about 11 feet on the crossing and to Barbre's, and as the tugs

and boat were not doing any dredging, I deemed it advisable to suspend work temporarily until waters hould begin to fall again.

Made several trips after that date with steamer Painter No. 2, sounding and staking channel; water still continued to rise, and on December 9, having received instructions from you to suspend operations and return fleet to New Orleans, I immediately made preparations and left on the 10th; arrived at New Orleans and turned fleet over to Mr. Fagan on the 12th.

In coming out I found an average depth of 20 feet all the way through, with a very rapid current towards the Mississippi River, which was fully 2 miles faster out of Upper Old River. If fleet had not been sent as early as it was, I think that the crossing, as it is called, would have run completely dry, and old steamboat men agree with me.

The space I have worked in steady was a distance of 4 or 4½ miles, and it was sometimes nine and ten o'clock at night when I stopped work. After the water fell and the channel narrowed down the work was much easier, as the current assisted me a great deal.

Old residents say that every season heretofore boats have had trouble in the "Mud Hole," but this season they have had no trouble of any consequence, for which they think the fleet is to be thanked.

The greater part of the boats passing have done everything in their power to delay my work, and threw every obstacle they could in my way, though I rendered them every assistance in my power.

Very respectfully, your obedient servant,

ED. FLOOD,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

REPORT OF MR. W. MARSHALL REES, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March —, 1881.

MAJOR: I have the honor to present the following report upon an examination of the mouth of Red River and vicinity, in compliance with your orders of May 31, 1880.

I left this place June 8 and arrived at Red River Landing on the 12th. On the 14th I located at Barbre's Landing, at the upper mouth of Atchafalaya River, a central point from which to conduct the work. Regular work was begun on June 15, by measuring base lines on Atchafalaya River. Soundings were then taken on a cross-section passing through one end of the base. This manner of working was continued on Lower Old River, and the sounding bases were afterwards connected throughout the whole extent of the survey by transit lines. Checked levels were run over all stations, and connected with the water-gauge at Red River Landing, and with the line of levels run along the Mississippi River by the Coast Survey party in the spring of 1880. The survey was also extended along the west bank of the Mississippi River to above Carr's Point Landing, or 2 miles above the lower mouth of Red River. Stations along this line were properly secured for future reference, so as to determine at any time the extent to which the bank in this vicinity caves.

Discharge observations were made at three places: On Red River about a half mile above the upper mouth; on the Atchafalaya about a mile below its upper mouth; and midway between the lower mouth of Red River and Turnbull's Island.

A gauge was established at the junction of Old and Atchafalaya rivers, upon which readings were taken twice a day. Daily readings were taken on a gauge at the foot of Turnbull's Island, by Capt. M. B. Lydon, of the United States dredge-boat Lone Star. The zeros of these gauges were on the same level and .325 foot above the zero of the Red River Landing gauge. A record of gauge readings is shown in I, annexed to this report. The column of remarks, in this table, is taken from the gauge record at Barbre's Landing.

At the time of my arrival a slow current was coming out of Old River. This gradually decreased until June 19, when no current could be detected. On the 26th a very slow current was found moving up Old River towards the Atchafalaya. This continued to increase (see discharge observations on Old River) until on July 8 the mean velocity was 2.339 feet per second, and, on the 20th, 4.093 feet per second. On July 31 the current was again nil, and a few days later, August 4, changed towards the Mississippi, maintaining this direction until September 6, when, a rise occurring in the Mississippi, the flow reversed to the Atchafalaya, in which direction it continued until September 24, when for two days no appreciable current could be found, and, on the 26th, the river falling rapidly, the current again changed to the Mississippi, and on October 15 it reversed for the third time to the Atchafalaya.

During the high-water of July the water flowed through Upper Old River to the head of Turnbull's Island, and thence down Lower Old River into the Atchafalaya. At the time of the second change of flow to the Atchafalaya, in September, Upper Old River was dry at the head of the island.

The velocities, in feet per second, at the gauging section on Old River, were, on August 7, 0.889; on August 20, 2.503; and on October 11, 1.080; all towards the Mississippi. The strongest current was on or about August 20.

Recapitulating.—During the four months from June 15 to October 17, the direction of the current changed five times.

	Days.
Flowed towards the Mississippi	56
Flowed towards the Atchafalaya	56
No appreciable current	13

CHANGES IN CROSS-SECTIONS.

In order to determine what changes were taking place in the Atchafalaya and Lower Old Rivers, cross-sections were taken at various places, the positions of which are shown upon the accompanying maps. The section stakes were secured for future use by marking trees, &c., near them, usually by marking the figure or letter of the section on a blazed portion of the tree by means of tacks; a proper record was made in the note books.

The number of sections located were, on the Atchafalaya, eleven; on Old River above the Atchafalaya, four; below the Atchafalaya, twenty-two; on Red River above the upper mouth, one; whole number, thirty-eight; of these, nine were sounded five times, twenty-six four times, one three times, and two twice. When the last series of observations were made, fourteen additional sections, on Lower Old River, were sounded; making a total of one hundred and seventy sets, all of which are shown on the annexed cross-section sheets. The soundings were located in the usual manner, by intersecting sights from two transits, one at each end of a carefully measured base, and the depths were carefully determined by two men reading a lead line which was tested before and after sounding, and proper corrections made if required.

The results of these observations are shown in Table III. The gauge referred to is that at the upper mouth of Atchafalaya. Low-water of 1872 at Red River Landing reads on this gauge —.325 foot, and high-water of 1874 reads 46.725 feet.

ATCHAFALAYA RIVER.

The second set of soundings taken upon this river show, upon comparison with the first set, that six sections were increased in area or scoured, and five sections decreased or filled, the scours exceeding the fills by about one-third.

In the interval between the times of these soundings a rise occurred, and the second set was taken at the top of the rise. When the third set of observations were taken the river had fallen over 14 feet. Comparing this set with the second, all sections show fills of considerable amount, except one which shows a small scour. Upon comparing the third set, taken August 16 and 17, with the last set, taken October 5 and 6, we find both scours and fills. Five sections show scours of from 7 to 298 square feet, and six fills of from 56 to 599 square feet. In the interval between the times of these soundings a rise occurred. On September 6 the gauge read 9.7, increasing to 13.6 on September 21; thence decreasing to 10.4 at the time of the last soundings.

On September 18, and near the top of the rise, four sections, near the upper mouth of the river, were sounded; each shows a small fill upon comparison with the third set.

Comparing the first set with the last, during which time the water fell about 15 feet, we find that all sections, with but one exception, have filled, the quantities varying from 330 to 2,420 square feet, or from 1.3 to 9.3 per cent.

The per cent. here and elsewhere is calculated by taking the area of cross-sections below 30 feet as 100 per cent.

The exception above noted, where a scour took place, was on the section through the eddy, at the mouth, the total scour on which was 878 square feet.

Reviewing these results, the greatest scours are shown by the soundings taken in the latter part of July, or just after the river had been rising most rapidly, and the greatest fills by those between July 23 and August 16, the river during this time falling rapidly. Hence the conclusion that during rising water the cross-section of the river enlarges, and during falling water the reverse takes place. This is verified by the results obtained on Old River, as we shall see further on.

For the better comparison of the changes which took place in that portion of Red River called Lower Old River, I divided it into three parts.

ABOVE THE ATCHAFALAYA.

In this portion the direction of flow is always the same, or towards the Atchafalaya. Four sections were examined, the farthest being about a mile above the Atchafalaya; each section was examined four times. But one section, A, shows a material scour; this occurred during the rise in July; one other section, C, shows a very small scour at this time, while the others show fills.

Subsequent soundings show fillings, except on the section just above the Atchafalaya, which between August 21 and October 8 scoured to the amount of 152 square feet.

Comparing the first and last soundings, we find fills on every section; the least, 700 square feet or 1.7 per cent., being on section D, and the greatest, 1,098 square feet or 2.4 per cent., on section C.

FROM THE ATCHAFALAYA TO THE CROSSING BELOW CHANDLER'S WAREHOUSE.

I have taken this portion separately, for the reason that, being much wider at ordinary low-water than the river below, the conditions under which changes take place are somewhat different.

Nine sections were located in this portion of the river, the second examination of which showed that all had scoured considerably, the quantities varying from 166 to 1,976 square feet. During this time the river was rising and flowing into the Atchafalaya. Subsequent examinations made during falling water showed fills in nearly all cases, the only important exception being on section Z on the crossing which between August 26 and October 7 scoured 2,818 square feet or 6.3 per cent. This scour was caused in part by the operations of the steam-tugs under Captain Flood in making a channel through the bar.

Comparing the first and last soundings, sections I and Z show scour, the former, which is just below the Atchafalaya, of 122 square feet, and the latter, as shown above, of 2,818 square feet; all other sections filled from 1,898 square feet or 4 per cent. on section F, to 3,462 square feet or 5.4 per cent. on section J; the greater part of the fill on the latter section was on the right side of the lower bar, the channel being on the left side.

FROM THE CROSSING TO THE LOWER MOUTH.

The portion of the river from the crossing to the foot of Turnbull's Island is what is known as "The Gut," so called on account of its narrowness, the widths, at 8 feet on the gauge, varying from 300 to 375 feet. There are nine sections here, from K to T, inclusive. In calculating the areas of cross-section for comparison, only that portion is taken between the left bank and the top of the bar, with the single exception of section K at the upper end, the entire cross-section of which is used. The greater portion of the large bar mentioned is covered with a thick growth of willows.

Comparing the first and second set of soundings, we see that sections K, L, and M filled, while all others scoured, except R. In the interval between the soundings the river rose and the water flowed towards the Atchafalaya. On the three sections where fills occurred the bar was comparatively low and covered with water, varying in depth, on these sections, from 5 to 9 feet. The greatest fill took place where the bar was lowest. On the other sections the water did not reach the top of the bar, or the thick growth of willows acted like a bank to confine the water in a channel of uniform width.

Hence scours took place here. Section K shows fills on every examination.

The soundings taken on August 24 and 25, with the water falling and the current towards the Mississippi, shows for sections L, M, and N, scours, and for O, P, R, S, and T, fills. Those taken on October 12, during still lower water, show scours for all sections except S and T, which filled.

Comparing the first and last soundings, sections K and L, and R, S, and T, being the sections at each end of "The Gut," show fills, varying from 72 square feet or .5 per cent. on section L to 2,120 square feet or 11.8 per cent. on section T.

Sections M, N, O, and P, in the middle of "The Gut," show scours of from 246 square feet or 1.5 per cent. on section P, to 550 or 3.2 per cent. on section O. The greater changes took place on section T, just above the foot of Turnbull's Island, where, between June 30 and July 31, the scour was 902 square feet or 5.3 per cent., and between July 31 and August 25 the fill was 2,732 square feet or 15 per cent.

In the first case the river was rising and flowing towards the Atchafalaya, and in the second case falling and flowing towards the Mississippi.

Three sections were taken at the lower mouth of the river, and one midway between the mouth and the foot of Turnbull's Island. Section Y, the upper one of the three at the mouth, was examined but twice, both times in low-water, and shows but little change.

All the others show marked changes, filling continually, the greatest fills taking

place during high-water, when the current moved towards the Atchafalaya, carrying in sediment from the Mississippi. The total fills are: for V, the gauging section, 2,378 square feet, or 11.6 per cent.; for those across the mouth, M = 3,927 square feet, or 11.5 per cent.; and W = 2,134 square feet, or 6 per cent.

SOME CHANGES WHICH HAVE TAKEN PLACE IN LOWER OLD RIVER SINCE 1878.

In December, 1878, Mr. Emil Steger, civil engineer, made a survey of this portion of Red River, and took a number of cross-sections, five only of which are useful for comparison with mine; of these, one is just above the Atchafalaya, corresponding to my section D. Another, just below the Atchafalaya, corresponding to section E, two at the foot of Turnbull's Island, corresponding to sections T and T^1, and the last at the lower mouth of Red River, corresponding to section W_2.

These show, at each place, a decrease in the area of cross-sections as compared with the soundings of two years ago. Thus, on section D, the fill was 1,768 square feet or 3.6 per cent., and on section E 14,181 square feet or 28 per cent. Sections T and T 1, which are 500 feet apart, filled 7,906 and 10,461 square feet or 34 per cent., and 43 per cent., respectively, and at the lower mouth the fill was 3,005 square feet or 7 per cent.

A number of sections were sounded by Steger in "the gut," but as the positions of the soundings were not located by angles they cannot be used for comparisons of areas; some, however, I have used to compare channel depths and heights of the bar. These correspond with sections N, O, P, R, and S. Since 1878 they have filled in the channel from 0 to 3 feet, and on the bar from 5 to 8 feet. On Steger's profile the bottom is marked "very soft mud," and a lower line shows the hard bottom. At the time of my soundings the bottom at this place was hard.

Steger's sections were sounded December 27, 1878, gauge 25.3; my sections were sounded October 12, 1880, gauge 8.4. On August 28, 1879, I made careful soundings on section 4, Atchafalaya River. Comparing these with soundings taken on October 5, 1880, I find a scour of 447 square feet. At the time of the first soundings the gauge read 8.7 feet, and at the time of the last 10.4 feet.

LONGITUDINAL PROFILE.

I have made a profile of the channel depths at Lower Old River, from a mile above the Atchafalaya, to the lower mouth. The channel depths, as determined by Steger in November, 1878, are placed upon the same sheet for direct comparison. For the first half mile above the Atchafalaya the depth has increased but little; for the second half mile the average increase in depth is about 8 feet. Below the Atchafalaya the depth has decreased throughout, except at one place near the lower mouth.

From the Atchafalaya to the crossing the fill is from 8 to 10 feet; from the crossing to below the Ash Cabin 4 to 6 feet; in the "Mud Hole" 1 to 2 feet; at the foot of Turnbull's Island 8 to 12 feet; midway between the island and the mouth and on the the bar at the mouth the depths are about the same as in 1878.

DISCHARGE OBSERVATIONS.

These were conducted at three places: 1st. Above the upper mouth of Red River; 2d, above the lower mouth of Red River, and below Turnbull's Island; and 3d, on the Atchafalaya, the object being to find out how the waters of the Red River were distributed when the flow was towards the Mississippi, and the amount which the Missssippi supplied to the Atchafalaya when the direction was reversed.

At the time of the first and second observations on Red River the waters of the Mississippi were flowing towards the Atchafalaya, and also around the north side of Turnbull's Island, backing up the waters of Red River. When the second observation was taken July 19, the river being near its highest stage, the water which poured out of Upper Old River retarded the flow in Red River to such an extent that, at the gauging station, over a half mile above the mouth, the current along the left bank was moving up stream, although very slowly, in the middle it was stationary, and on the right bank flowed down. The discharge, approximately determined, was only 66.95 cubic feet per second.

The greatest discharge of Atchafalaya was on July 20 = 86,530 cubic feet per second, of which 81,604 cubic feet, or 94 per cent., came from the Mississippi. On October 9, at the time of the lowest water, Red River discharged 27,505 cubic feet, of which 23,758 cubic feet, or about 85 per cent., passed into the Atchafalaya, and 4,238 cubic feet, or 15 per cent., into the Mississippi.

The high-water cross-section of the Atchafalaya gauging section is 36,731 square feet. Taking the highest observed mean velocity, 3.5 feet per second, this will give a discharge of 128,558 cubic feet per second; but the velocity at high-water will be much greater than this. Examining Table II we see that the mean velocities increase about

1 foot for each foot of rise; hence, at high-water, or 47.05 feet, the mean velocity will probably reach, if not exceed, 5 feet per second; at this rate the discharge would be 183,655 cubic feet per second.

LEVELS, SLOPES, ETC.

At the times of making soundings the elevations of the water surface were taken at different points, whenever this was thought necessary. As the Atchafalaya is of about the same width throughout the length of my survey, levels were taken only at the farthest section, No. 12, 3.36 miles below the upper mouth.

These showed a fall of from .417 to .440 foot in this distance, or 1.47 to 1.56 inches per mile. During June and July the gauges at Barbre's, and the foot of Turnbull's Island, read almost the same, so that no corrections were required for the first and second sets of soundings on Old River. They were made for subsequent soundings, as the gauges differed by as much as 1.75 foot. To make proper corrections water-levels were taken at several points, and intermediate points determined by interpolation. The greatest slope observed was in the gut, on October 11, of 4 inches per mile. A few days before this, as shown by the greater differences in gauge readings, the slope was still greater, probably as much as 5 inches per mile.

The datum to which all levels are referred is the zero of the gauge at Barbre's Landing.

BENCH-MARKS.

Barbre's Landing: A cut on the root of a large locust tree near the warehouse; elevation, 46.550 feet.

Above section 12, and 3¼ miles below the mouth of the Atchafalaya: A cut on the root of a large pecan tree between the levee and the river; elevation, 44.730.

Lower mouth of Red River: A cut on the root of a cotton-wood tree which stands on the right bank, and about 300 feet north of section W; elevation=40.104.

No. 127 of the Coast and Geodetic Survey: A stake driven in the levee on its outer side, about 30 meters above a large white warehouse (Toras's), which stands outside of the levee at the upper end of Red River Landing: A nail driven in the top of the stake marks the bench elevation, 48.294 feet.

The elevation of this bench mark referred to the Coast Survey bench mark at Carrollton, Louisiana, is +13.0430 meters, and referred to Hampson's bench mark, same place, +13.2483 meters.

Red River Landing: A cut on the root of a large tree in front of Kingsbury's store; to this tree is spiked the top portion of the gauge here; elevation=41.073 feet.

This bench reads on the the Red River Landing gauge 42.073.

THE BANKS, BARS, AND RIVER BED.

The banks of the Atchafalaya are similar throughout the part examined. Towards the top is a greenish loam and buckshot, then a layer of red clay, and under this in many places the characteristic blue clay of the Mississippi, the layers of which are frequently inclined or unconformable with the overlying deposits. The river bed is hard, generally of clay. The banks do not cave easily. The only caving I noticed was near the upper mouth, where, on August 18, a piece of the bank 400 feet long and from 5 to 20 feet wide broke off, the wide end dropping about 10 feet, leaving the caved portion nearest the river much the highest; this is the usual manner in which the caves take place, as illustrated by the many sharp points shown on the cross-sections. Other caves of less extent occurred for about 1,000 feet below. The high-water banks on Old River are about the same as on the Atchafalaya.

An examination of the maps will show the locations and elevations of the bars and the materials of which they are composed. On Lower Old River there are two large bars; one starts from near the head of Turnbull's Island. Opposite Section A its elevation is 40 feet, and opposite Bayou Moro its elevation is 8 feet. In August, 1879, when the gauge was at 8 feet, the point of this bar was at least three-fourths of a mile above the bayou. The other bar extends from opposite the foot of Turnbull's Island to the crossing below Chandler's Landing. The elevation opposite Turnbull's Island is 32 feet; opposite Ash Cabin, 25 feet, trailing out to 10 feet on Section X.

Both bars are rapidly enlarging. On the channel sides they are firm, being covered with a deposit of sand; on their opposite sides they are composed of very soft material, which will not bear the weight of a man until a long time after the water leaves it.

A bar is also forming opposite Chandler's Landing; its present elevation is about 11 feet; it is of very soft material, so soft that a 9-foot oar was pushed its length in the bottom with ease. It is very probable that by next summer the pockets shown now at 8 feet of water will be filled. The river bed from Waverly Landing to the crossing is of very soft material; from the crossing to the foot of the island for the most part hard;

between the island and the mouth, soft, but here the soft deposit is not nearly as thick as above the crossing.

The bar at the mouth is of sand, the grains of which are considerably larger than of the bars above. It is observed in passing up the river that the sand grains decrease in size. As this sand comes from the Mississippi the coarser is dropped near the mouth and the finer carried to the Atchafalaya.

For two-thirds of a mile above the crossing the depth is only 5 feet when the gauge reads 8 feet above low-water. Had the water fallen as low as in 1879, when it reached 0.65 on the Red River Landing gauge, without inducing a sufficient current through this place to scour the bottom, which would have occurred if both rivers had fallen at the same rate, then this portion would have closed. This result was possible. The probabilities, however, were that a difference of level between the two rivers would exist and cause a confined current to cut out this soft bottom to some extent.

The increase of the bar opposite Chandler's will confine the water here and make a stronger current, which will wash out this soft deposit.

As an illustration of the rapidity with which this river fills, my examination shows that between July 27 and August 23 the channel for 1 mile above the crossing filled from 2 to 2.8 feet; for a length of at least one-half mile above the foot of the island the fill between July 31 and August 25 was 2.6 feet, and during the same period at the foot of the island the fill was 10.3 feet.

Half way between the island and the lower mouth the fill was 2.6 feet between August 7 and August 20.

A careful examination of the results obtained and comparisons with the sections taken in 1878 shows that Lower Old River is rapidly filling up, and that the difficulty of keeping a channel open by dredging will increase each year.

In order to determine what changes are taking place in the Atchafalaya, it will be advisable to allow a full season of high-water to elapse between examinations, when, I think, the resultant scours will considerably exceed the fills, and it is probable that under the present conditions the enlargement will go on until the Atchafalaya is of sufficient size to carry all of Red River water.

A further examination of Old River will prove conclusively the rapidity with which the bed is filling. This examination should be made at mean and low water to determine the extent of increase on the bars.

The map embraces a portion of the Mississippi River above the mouth of Red, showing soundings on Angola Bar.

The large bar in the Mississippi below the mouth of Red and in front of Red River Landing is increasing in size. It showed itself on January 15 when the Red River Landing gauge read 10 feet as distinctly as on October 15, when the gauge read 8 feet. The highest point of the bar is now opposite Fora's warehouse, while in the fall of 1879 it was but a short distance above Red River Landing.

Before closing this report I wish to acknowledge the valuable assistance rendered by Mr. I. B. Roher, assistant engineer, in the field.

Accompanying this report are:

Map of the mouth of Red River and vicinity, survey of 1880; cross-sections of mouth of Red River and vicinity, survey of 1880.

Longitudinal profile Lower Old River.

Three sheets of cross-sections comparing survey of 1880 with survey of 1878, &c.

Very respectfully, your obedient servant,

W. MARSHALL REES,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

All the cotton and freight transported to New Orleans from the Red River, Ouachita River and its tributaries, and the Atchafalaya River passed out through the mouth of Red River, to which should be added a corresponding amount of return freight.

These different amounts are set forth in the reports on those streams.

Gauge Record, Barbre's Landing, 1880.

Date.	Barbre's Landing.	Foot of Turnbull's Island.	Remarks.	Date.	Barbre's Landing.	Foot of Turnbull's Island.	Remarks.
	Feet.	*Feet.*			*Feet.*	*Feet.*	
June 1	.....	.....		Aug. 4	22.65	22.6	Current to the Mississippi.
2	.....	.....		5	21.75	21.75	
3	.....	.....		6	20.95	20.9	
4	.....	.....		7	20.2	20.1	
5	.....	.....		8	19.5	19.3	
6	.....	.....		9	18.8	18.55	
7	.....	.....		10	18.3	17.9	
8	.....	.....		11	18.0	17.35	
9	.....	.....		12	17.6	16.7	
10	.....	.....		13	17.1	16.15	
11	.....	.....		14	16.7	15.6	
12	.....	25.2	Current to the Mississippi.	15	16.3	15.1	
13	.....	25.3		16	15.9	14.6	
14	.....	25.4		17	15.5	14.1	
15	26.8	25.4		18	15.1	13.7	
16	26.7	25.3		19	14.8	13.4	
17	26.5	25.1		20	14.5	13.0	
18	26.2	26.1		21	14.2	12.7	
19	25.8	25.8	No current.	22	13.9	12.5	
20	25.4	25.3		23	13.6	12.1	
21	25.0	24.9		24	13.36	11.8	
22	24.6	24.4		25	13.0	11.5	
23	24.1	24.0		26	12.9	11.2	
24	23.6	23.4		27	12.55	11.0	
25	23.1	23.0		28	12.25	10.8	
26	22.6	22.5	A very slow current to the Atchafalaya.	29	11.9	10.6	
27	22.2	22.2		30	11.6	10.2	
28	22.0	22.0		31	11.3	9.7	
29	21.85	21.85		Sept. 1	.....	9.3	
30	21.9	21.95		2	.....	9.1	
July 1	22.2	22.2	Current to the Atchafalaya.	3	.....	9.3	
				4	10.1	9.5	
2	22.5	22.6		5	9.9	9.6	
3	22.9	23.0		6	9.7	9.9	Current changed to the Atchafalaya.
4	23.2	23.55		7	9.9	10.15	
5	23.7	24.0		8	10.3	10,5	
6	24.1	24.5		9	10.7	10.75	
7	24.5	24.85		10	11.0	11.15	
8	24.9	25.15		11	11.45	11.55	
9	25.1	25.35		12	11.8	11.9	
10	25.3	25.6		13	12.1	12.2	
11	25.6	25.95		14	12.5	12.6	
12	26.0	26.4		15	12.9	13.05	
13	26.5	27.0	Drift from the Mississippi running into the Atchafalaya.	16	13.1	13.25	
				17	13.25	13.35	
14	27.1	27.6		18	13.4	13.5	
15	27.7	28.2		19	13.6	13.7	
16	28.2	28.7		20	13.6	13.75	
17	28.7	29.1		21	13.65	13.75	
18	29.1	29.5		22	13.5	13.6	
19	29.3	29.8		23	13.1	13.3	
20	29.5	29.95		24	13.0	13.1	No current.
21	29.7	30 1		25	12.6	12.8	
22	30.0	30.3		26	12.1	11.85	Current to the Mississippi.
23	30.0	30.35		27	11.7	11.25	
24	29.9	30.2		28	11.35	10.75	
25	29.6	30.0		29	11.2	10.3	
26	29.35	29.6		30	11.0	10.05	
27	28.9	29.15		Oct. 1	10.9	9.75	
28	28.35	28.5		2	10.65	9.45	
29	27.8	27.9		3	10.5	9.15	
30	27.1	27.25		4	10.4	8.9	
31	26.3	26.2	No current.	5	10.4	8.8	
Aug. 1	25.3	25.2		6	10.4	8.7	
2	24.3	24.25		7	10.35	8.6	
3	23.5	23.5		8	10.2	8.45	

Gauge Record, Barbre's Landing, 1880—Continued.

Date.	Barbre's Landing.	Foot of Turnbull's Island.	Remarks.	Date.	Barbre's Landing.	Foot of Turnbull's Island.	Remarks.
	Feet.	*Feet.*			*Feet.*	*Feet.*	
Oct. 9	10.1	8.4		Oct. 20	.....	7.8	
10	9.9	8.4		21	.....	7.5	
11	9.7	8.3		22	.....	7.25	
12	9.4	8.3		23	.....	6.9	
13	9.1	8.25		24	.....	.....	
14	8.8	8.3		25	.....	.....	
15	8.4	8.35	Current to the Atchafalaya.	26	.....	.....	
				27	.....	.....	
16	8.2	8.4		28	.....	.....	
17	7.9	8.3		29	.....	.....	
18	.....	8.15		30	.....	.....	
19	.....	8.0		31	.....	.....	

TABLE II.

ATCHAFALAYA RIVER.

Date.	Gauge.	No. of floats run.	Area of cross-sections.	Mean velocity per second.	Discharge per second.	Remarks.
	Feet.		*Square feet.*	*Feet.*	*Cubic feet.*	
July 6	24.1	67	21,333	3.081	65,729.94	Wind, 0 to 1.
July 21	29.7	55	24,717	3.501	86,530.53	
Aug. 5	21.7	40	19,613	2.531	49,644.10	Wind, 1 to 2 down.
Aug. 19	14.8	51	15,684	2.050	32,143.66	
Oct. 8	10·2	52	13,178	1.803	23,757.99	Wind, 1 across.

RED RIVER, ABOVE UPPER MOUTH.

July 5	23.7	88	43,126	0.553	23,851.35	Retarded by backwater from the Mississippi.
July 19	29.3	39	49,792	.....	6,693.52	Do.
Aug. 6	20.8	89	40,315	1.309	52,765.64	Wind, 1 down.
Aug. 18	15.1	72	33,219	1.557	51,731.48	Wind, 0 to 1 down.
Oct. 9	10.1	61	25,553	1,076	27,505.94	

LOWER OLD RIVER, ABOVE THE MISSISSIPPI.

July 8	25.0	78	16,858	2.339	39,420.47	To the Atchafalaya.
July 20	29.6	45	19,935	4.093	81,603.92	Do.
Aug. 7	20.1	25	12,180	0.889	10,829.74	To the Mississippi.
Aug. 20	12.8	38	6,799	2.503	17,020.79	Do.
Oct. 11	8.1	40	3,923	1.080	4,238.27	Do.

TABLE III.

ATCHAFALAYA RIVER.

Section.	Date.	Gauge.	No. of soundings.	Areas of cross-section below 30 feet.	Change.		Channel depth below 8 feet.	Areas.		Widths.	
					Scour.	Fill.		High-water.	At 8 feet.	High-water.	At 8 feet.
	1880.	*Feet.*		*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*
2	July 3	22.9	87	57,605	.....	.....	77.0				
2	July 28	28.2	62	59,744	2,139	.....	80.3				
2	Aug. 21	14.1	53	58,185	.....	1,559	75.7				
2	Oct. 5	10.4	37	58,483	298	.....	75.4	76,917	37,971	1,130	824
3	June 16	26.7	21	32,556	.....	.....	59.8				
3	July 24	29.8	52	33,291	735	.....	60.8				
3	Aug. 16	15.9	45	30,722	.....	2,569	55.3				
3	Sept. 18	13.4	36	30,515	.....	207	55.3				
3	Oct. 5	10.4	41	30,652	137	.....	55.3	43,465	16,769	820	547
4	June 16	26.7	27	24,713	.....	.....	45.8				
4	July 23	30.0	38	23,357	.....	1,356	40.9				
4	Aug. 16	15.9	47	22,447	.....	910	39.7				
4	Sept. 18	13.4	32	22,344	.....	103	40.3				
4	Oct. 5	10.4	35	22,454	110	.....	39.3	35,289	9,528	852	425
	1879.										
4	Aug. 28	8.7	63	22,007	.....	447	40.1				
	1880.										
5	June 16	26.7	35	25,887	.....	.....	41.0				
5	July 23	30.0	43	24,622	.....	1,265	39.1				
5	Aug. 16	15.9	50	23,692	.....	930	36.1				
5	Sept 18	13.4	41	23,552	.....	140	35.6				
5	Oct. 5	10.4	39	23,467	.....	85	36.1	36,731	10,180	816	417
6	July 6	24.1	48	25,031	.....	.....	35.8				
6	July 21	29.7	48	24,927	.....	104	35.–				
6	Aug. 5	21.7	39	24,870	.....	57	34.8				
6	Aug. 18	15.0	45	24,590	.....	280	35.0				
6	Oct. 8	10.2	47	24,451	.....	139	34.0	38,089	12,083	855	493
7	June 23	24.1	42	26,916	.....	.....	48.2				
7	July 23	30.0	43	27,356	440	.....	48.7				
7	Aug. 16	15.7	48	26,885	.....	471	47.0				
7	Sept. 18	13.4	45	26,423	.....	462	46.5				
7	Oct. 5	10.4	47	26,286	.....	137	46.5	38,896	12,150	800	504
8	June 23	24.1	36	24,772	.....	.....	42.0				
8	July 23	30.0	38	24,517	.....	255	42.0				
8	Aug. 16	15.7	53	24,847	330	.....	44.4				
8	Oct. 5	10.4	29	24,442	.....	405	44.0	36,218	11,713	720	483
9	June 22	24.6	48	28,469	.....	.....	53.0				
9	July 23	30.0	46	28,417	.....	52	53.0				
9	Aug. 17	15.4	41	27,277	.....	1,140	48.6				
9	Oct. 5	10.4	29	27,468	191	.....	47.4	39,605	15,158	755	457
10	June 22	24.6	48	32,829	.....	.....	38.6				
10	July 24	29.9	53	32,295	466	.....	37.6				
10	Aug. 17	15.4	62	31,664	.....	1,631	36.4				
10	Oct. 6	10.4	40	31,718	54	.....	36.1	45,596	15,981	855	640
11	June 21	24.8	47	31,087	.....	.....	40.0				
11	July 24	29.9	46	31,467	380	.....	40.0				
11	Aug. 17	15.4	53	30,612	.....	855	38.2				
11	Oct. 6	10.4	34	30,556	.....	56	37.5	45,080	15,362	895	610
12	June 21	24.8	44	33,151	.....	.....	44.0				
12	July 24	29.9	49	33,169	18	.....	44.7				
12	Aug. 17	15.4	45	32,514	.....	655	42.5				
12	Oct. 6	10.4	42	32,544	39	.....	43.0	46,343	16,372	840	665

RED RIVER ABOVE UPPER MOUTH.

A A ..	July 5	23.7	63	50,840	.....	.....	34.5				
A A ..	July 19	29.3	84	50,662	.....	178	33.5				
A A ..	Aug. 5	21.4	62	51,500	838	.....	35.5				
A A ..	Aug. 14	15.3	62	51,012	.....	488	35.1				
A A ..	Oct. 9	10.1	38	48,894	.....	2,118	30.7	.....	23,338	1,290	1,042

LOWER OLD RIVER.

Above the Atchafalaya.

Section.	Date.	Gauge.	No. of soundings.	Areas of cross-section below 30 feet.	Change.		Channel depth below 8 feet.	Areas.		Widths.	
					Scour.	Fill.		High-water.	At 8 feet.	High-water.	At 8 feet.
	1880.	*Feet.*		*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*
A	June 18	26.0	62	64,090	.....	.....	38.4				
A	July 26	29.3	71	64,666	576	.....	38.4				
A	Aug. 19	14.7	74	63,664	.....	1,002	37.8				
A	Oct. 6	10.4	47	63,084	.....	580	37.6	98,190	24,222	3,300	1,320
B	June 18	26.0	40	50,708	.....	.....	46.4				
B	July 26	29.3	57	50,522	.....	186	45.0				
B	Aug. 19	14.7	45	49,880	.....	642	43.5				
B	Oct. 6	10.4	34	49,674	.....	206	43.4	.....	27,074	*1,680	820
C	June 23	24.0	57	45,208	.....	.....	41.2				
C	July 26	29.3	58	45,288	80	.....	42.0				
C	Aug. 21	14.2	51	44,512	.....	776	39.2				
C	Oct. 8	10.2	40	44,190	.....	322	38.8	.....	20,200	*1,400	860
D	June 23	24.1	47	42,830	.....	.....	40.2				
D	July 26	29.2	58	42,786	.....	44	40.2				
D	Aug. 21	14.2	42	41,978	.....	808	39.3				
D	Oct. 8	10.2	37	42,130	152	.....	.....	.....	20,404	*1,200	860

Below the Atchafalaya.

1	June 23	24.1	49	32,028	.....	.....	16.3				
1	July 28	28.3	58	32,450	422	.....	20.7				
1	Aug. 26	12.6	48	32,392	.....	58	19.9				
1	Oct. 8	10.2	32	32,150	.....	242	19.5	.....	7,050	*1,650	720
E	June 24	23.6	57	45,546	.....	.....	23.4				
E	July 26	29.2	66	46,474	928	.....	22.6				
E	Aug. 23	13.6	34	43,640	.....	2,834	22.2				
E	Oct. 8	10.2	27	43,310	.....	330	20.4	95,078	5,800	3,425	415
F	June 24	23.5	68	47,084	.....	.....	14.1				
F	July 26	29.2	57	47,930	846	.....	15.3				
F	Aug. 23	13.5	45	46,194	.....	1,736	12.9				
F	Oct. 7	10.2	38	45,186	.....	1,008	10.5	87,348	3,434	2,800	500
G	June 25	23.1	86	49,768	.....	.....	7.4				
G	July 27	28.7	63	50,332	564	.....	7.5				
G	Aug. 23	13.4	44	47,408	.....	2,924	4.7				
G	Sept. 20	13.4	39	47,572	164	.....	5.7				
G	Oct. 7	10.0	28	47,254	.....	318	5.3	91,462	1,782	2,850	600
H	June 25	23.0	90	50,882	.....	.....	7.4				
H	July 27	28.7	71	51,546	664	.....	6.2				
H	Aug. 23	13.4	46	49,250	.....	2,296	4.3				
H	Sept. 20	13.4	56	48,922	.....	328	4.6				
H	Oct. 7	9.9	27	48,808	.....	114	4.2	95,506	1,442	2,865	587
I	June 26	22.4	150	43,476	.....	.....	4.8				
I	July 27	28.8	87	43,642	166	.....	5.6				
I	Aug. 23	13.3	41	41,728	.....	1,914	3.2				
I	Oct. 7	9.8	35	41,318	.....	410	4.6	80,928	1,516	2,660	625
J	July 2	22.5	109	64,262	.....	.....	10.7				
J	July 27	28.9	99	66,238	1,976	.....	10.2				
J	Aug. 23	13.2	52	60,986	.....	5,252	10.1				
J	Oct. 7	9.5	48	60,800	.....	186	9.6	110,364	2,470	3,070	370
K	June 29	21.8	110	73,298	.....	.....	11.0				
K	July 31	26.0	123	70,752	.....	2,544	11.0				
K	Aug. 24	12.9	41	69,328	.....	1,424	9.2				
K	Oct. 12	8.7	25	69,012	.....	316	9.2	136,032	1,918	4,100	315
L	July 2	22.6	92	16,374	.....	.....	11.4				
L	July 30	27.0	118	15,680	.....	694	9.6				
L	Aug. 24	12.7	53	16,304	624	.....	11.0				
L	Oct. 12	8.6	25	16,302	.....	2	11.0	.....	2,168	3,780	320
M	July 1	22.2	82	14,858	.....	.....	11.0				
M	July 30	27.0	121	14,602	.....	256	9.1				
M	Aug. 24	12.6	35	15,188	586	.....	8.3				
M	Oct. 12	8.6	28	15,316	128	.....	11.3	.....	2,180	*3,485	305
N	July 1	22.2	43	16,594	.....	.....	10.4				
N	July 30	26.8	65	16,652	58	.....	8.2				
N	Aug. 24	12.4	33	17,128	476	.....	8.8				
N	Oct. 12	8.5	26	17,144	16	.....	7.9	.....	2,090	*1,100	375

*To bar.

TABLE III.—*Atchafalaya River*—Continued.

Section.	Date.	Gauge.	No. of soundings.	Areas of cross-section below 30 feet.	Change.		Channel depth below 8 feet.	Areas.		Widths.	
					Scour.	Fill.		High-water.	At 8 feet.	High-water.	At 8 feet.
	1880.	*Feet.*		*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*
O	July 1	22.2	48	16,058	.....	.....	8.8				
O	July 30	26.7	47	16,446	388	.....	6.5				
O	Aug. 24	12.3	34	16,282	.....	164	7.4				
O	Oct. 12	8.4	26	16,538	256	.....	7.6	.....	1,936	*1,000	375
P	June 29	21.8	47	15,502	.....	.....	9.4				
P	July 31	26.2	54	16,038	536	.....	10.2				
P	Aug. 24	12.2	36	15,478	.....	560	8.2				
P	Oct. 12	8.4	25	15,748	270	.....	9.6	.....	1,952	*900	315
R	June 30	21.9	45	15,424	.....	.....	9.0				
R	July 31	26.2	55	15,182	.....	242	8.5				
R	Aug. 24	12.1	32	14,838	.....	344	5.9				
R	Oct. 12	8.3	26	15,206	368	.....	7.3	.....	1,702	*900	340
S	June 30	21.9	47	14,706	.....	.....	15.7				
S	July 31	26.1	60	15,232	526	.....	14.5				
S	Aug. 25	11.7	29	14,320	.....	912	11.9				
S	Oct. 12	8.2	25	13,832	.....	488	8.1	.....	2,270	900	340
T	June 30	21.9	43	17,296	.....	.....	16.6				
T	July 31	26.0	53	18,198	902	.....	26.3				
T	Aug. 25	11.4	34	15,466	.....	2,732	16.0				
T	Oct. 12	8.1	29	15,282	.....	184	15.0	.....	3,724	660	390
M	June 30	21.9	103	34,600	.....	.....	27.4				
M	Aug. 7	20.0	54	31,166	.....	3,434	35.4				
M	Aug. 25	11.0	43	30,898	.....	268	30.6				
M	Oct. 13	8.0	24	30,674	.....	224	30.1	.....	7,438	1,345	380
Y	Aug. 25	11.0	38	23,714	.....	.....	15.4				
Y	Oct. 13	8.0	18	23,756	42	.....	16.2	43,098	4,032	1,185	415
V	July 7	24.6	65	20,512	.....	.....	16.9				
V	July 20	29.6	47	20,234	.....	278	16.3				
V	Aug. 7	20.1	43	18,178	.....	1,046	14.3				
V	Aug. 20	12.8	47	17,342	.....	846	11.2				
V	Oct. 11	8.1	34	18,134	.....	208	11.7	.....	3,870	815	530
W	July 15	27.9	63	34,880	.....	.....	13.4				
W	Aug. 7	20.0	70	32,686	.....	2,194	6.9				
W	Aug. 25	11.0	50	32,658	.....	28	7.3				
W	Oct. 13	8.0	52	32,746	88	.....	6.3*	.....	1,646	.....	220
							7.7†	.....	654	1,730	108
X	Aug. 2	23.9	99	53,214	.....	.....	8.2				
X	Aug. 23	13.3	41	51,174	.....	2,040	5.7				
X	Oct. 7	9.6	54	51,124	.....	50	5.7	93,404	2,044	2,580	520
Z	Aug. 26	12.5	66	44,838	.....	.....	2.8				
Z	Oct. 7	9.7	38	47,656	2,818	.....	10.4	86,266	2,540	2,360	350
No. 10, Steger	1878, Dec. 10	12.7	.....	49,200	.....	.....	37.6	.....	.....	1,578	1,160
D, Rees.	1880, Oct. 8	10.2	.....	47,432	.....	1,768	39.3	.....	.....	1,550	860
No. 12, Steger	1878, Dec. 10	12.7	.....	50,401	.....	.....	30.6	.....	.....	1,590	1,340
E, Rees.	1880, Oct. 8	10.2	.....	36,220	.....	14,181	20.4	.....	.....	1,580	415
No. 14, Steger	1878, Dec. 19	23.3	.....	23,188	.....	.....	27.9	.....	.....	700	520
T, Rees.	1880, Oct. 12	8.1	.....	15,282	.....	7,906	15.0	.....	.....	605	390
No. 15, Steger	1878, Dec. 11	15.3	.....	24,122	.....	.....	28.6	.....	.....	694	567
T, Rees.	1880, Oct. 12	8.1	.....	13,661	.....	10,461	15.6	.....	.....	630	285
No. 18, Steger	1878, Dec. 26	25.4	.....	43,675	.....	.....	7.9	.....	.....	1,950	915
W 2, Rees.	1880, Oct. 13	8.0	.....	40,670	.....	3,005	8.3	.....	.....	1,927	.....

*900 to bar. *Right Chute. †Lydon's Cut.

P 5.

REMOVING RAFT IN RED RIVER AND CLOSING TONE'S BAYOU, LOUISIANA.

REMOVAL OF RAFT IN RED RIVER, LOUISIANA.

The steamer Florence, in charge of Capt. M. B. Lydon, was taken to Shreveport upon the approach of the high-water season, so as to be in readiness to keep the river clear of drift and prevent the formation of new raft.

Considerable work was done during the months of December, January, and February, and we were enabled to keep the river open to navigation. In some places raft had reformed, reaching nearly across the river, and extending to the bottom. Two of these jams, each about 500 feet in length, and one of 250 feet, were broken up; 83 side jams were also destroyed and 193 snags removed.

CLOSING TONE'S BAYOU, LOUISIANA.

As the appropriation of June 14, 1880, was not sufficient for both works, by letter from the department under date of September 3, 1880, I was authorized to withhold so much of the appropriation for raft and Tone's, as had been allotted for this latter work, and combine it with a portion of next appropriation, for building the earthen dam in Tone's Bayou and connecting with the levees on Red River. After the passage of the bill of March 3, last, specifications were issued and proposals called for for the work, to be opened June 23. But one bid was received, that of Alfred L. Gervin and John A. Bietry, for $23,550. The proposal of William Robson and S. J. Ward, offering to do the work for $37,000, did not reach me until the following day.

The raft work is not permanent; immense quantities of drift are brought down on each flood, which if not removed would cause an entire closure of the river in one season. It is necessary to have a boat to patrol the river from Shreveport to the head of the raft, and keep this drift in motion, and prevent it from lodging and forming new raft.

The original detailed estimate for the removal of the raft (see my report for fiscal year ending June 30, 1876, also previous report of Captain Howell) was $259,014, with additional items for keeping open the channel for fiscal year, $50,000; and for subsequent years it was estimated that from $10,000 to $25,000 would be required.

More land has been opened this year, and more money invested in cotton culture in the district tributary to Shreveport than in any other in the cotton belt, excepting perhaps in Texas. Many of the large planters are rapidly clearing new land and increasing the facilities of their plantations.

The above works are situated in the third collection district of Louisiana. The nearest port of entry is New Orleans.

During the coming season it is proposed to build Tone's Bayou dam, and employ the steamer Florence in keeping the river open during the flood seasons, and in removing certain portions of the old raft.

With the appropriation of $18,000 asked for, for the fiscal year ending June 30, 1883, it is proposed to keep the river open and remove old raft.

The former appropriations are as follows:

By act approved June 10, 1872	$150,000
By act approved March 3, 1873	80,000
By act approved June 23, 1874	50,000

By act approved March 3, 1875	$20,000
By act approved August 14, 1876, for removing raft and closing Tone's Bayou.	35,000
By allotment August 27, 1877, for closing Tone's Bayou	4,500
By act approved February 7, 1878, for removing raft	6,000
By act approved June 18, 1878, for removing raft and closing Tone's Bayou.	24,000
By act approved March 3, 1879, for removing raft and closing Tone's Bayou.	15,000
By act approved June 14, 1880, for removing raft and closing Tone's Bayou.	25,000
By act approved March 3, 1881, for removing raft and closing Tone's Bayou.	10,000

Money statement.

July 1, 1880, amount available	$26,634 76	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$36,634 76
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,452 12
July 1, 1881, amount available		31,182 64
Amount that can be profitably expended in fiscal year ending June 30, 1883.		18,000 00

The following is the abstract of the bid:

Abstract of proposals for building an earthen dam in Tone's Bayou, Louisiana, and connecting levees received in response to advertisement, dated May 14, 1881, *and opened June* 23, 1881, *by Maj. W. H. H. Benyaurd, Corps of Engineers.*

No.	Names of bidders.	Price.	Date of completion of work.	Remarks.
1	Alfred L. Gervin and John A. Bietry.	$23,550 for the whole work.	During low-water of 1881.	Specifications were not attached to proposals. Alterations of Bietry from Vietry on bidder's bond, and also name of Simon Hernsheim on bidder's bond not noted on the proposal over signature of bidders.

COMMERCIAL STATISTICS.

Shreveport is the principal distributing city for Red River, and for the nine months from September 1, 1880, to May 31, 1881, the following business was done:

Cotton shipped to New Orleans	bales..	86,646
Cotton seed shipped to New Orleans	sacks..	43,000
Oil cake shipped to New Orleans	do...	6,658
Oil meal shipped to New Orleans	do...	1,600
Oil shipped to New Orleans	barrels..	1,592
Grain and hay shipped to New Orleans	tons..	53
Wet hides shipped to New Orleans	pounds..	155,050
Dry hides shipped to New Orleans	do....	150,695
Wool shipped to New Orleans	do....	105,400
Tallow shipped to New Orleans	do....	10,000
Beeswax shipped to New Orleans	do....	14,000
Miscellaneous merchandise shipped to points on the river below Shreveport	tons..	5,000

The shipment of cotton from Shreveport to the East by rail this year amounts to 21,193 bales against 58,243 bales for the same time last year, while by river, via New Orleans, it amounts this year to 37,474 bales against 14,181 bales for the same time last year. This results from the fact that better through rates are offered by the steamboats.

The total receipts of cotton at Shreveport this year, up to June 1, amounts to 77,498 bales; this does not, however, include the cotton received by rail and from the Upper Red River for through shipments, but is the amount actually handled by the merchants of the city. This cotton was received as follows: 14,472 bales by river, 18,257 bales by rail, and 44,769 bales by wagon. A large amount of the cotton received by wagon

comes from the parishes east of Shreveport, and is brought across the river on the ferry-boat. About 3,500 bales were brought by steamboat from below, consigned to Shreveport merchants.

The number of steamboats running to and from Shreveport are 20; total tonnage of same, 64,630; value of annual imports (estimated), $11,253,960; value of annual exports (estimated), $5,537,600.

P 6.

REMOVING OBSTRUCTIONS FROM RED RIVER, LOUISIANA.

During the past season operations were carried on upon Red River with the snag-boat O. G. Wagner. The boat left the Ouachita, where she had been at work, and entered Red River October 15, 1880, and immediately commenced the work of removing the snags and other obstructions from the river.

The operations were carried on from the mouth to Riverdale, a point some 25 miles below Shreveport. Considerable work was done at many points, but notably at the Confederate raft, the Rapions, and the Falls of Alexandria.

The following is a summary of the work:

Number of snags removed	665
Number of trees cut down	768
Number of shore snags destroyed	448

For details of the operations I beg leave to refer to the report of Capt. E. F. White herewith.

A contract was entered into early in February of this year for the construction of an iron hull stern-wheel snag-boat for work in this river. The boat is nearly completed, and it is expected will be ready for delivery about the 1st of August.

During the coming season it is proposed to send the new snag-boat into Red River as soon as she is completed, for the purpose of carrying on the operations, as has been done heretofore, the estimated cost of her running expenses for eight months work, and incidentalexpenses, being $24,000.

As the work must necessarily be continuous, new obstructions being added each year, no project with detailed estimates has been submitted.

The appropriation of $28,000 asked for, for the present year ending June 30, 1883, will be expended in carrying on the operations of the snag-boat and in completing the outfit for the new boat.

The former appropriations are as follows:

By act approved June 18, 1878	$25,000
By act approved March 3, 1879	22,500
By act approved June 14, 1880, including cost of snag-boat	60,000
By act approved March 3, 1881	10,000

The above works are situated in the third collection district of Louisiana. The port of entry is New Orleans.

Money statement.

July 1, 1880, amount available	$60,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$70,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		27,276 81
July 1, 1881, amount available		42,723 19
Amount that can be profitably expended in fiscal year ending June 30, 1883		28,000 00

Abstract of proposals for building an iron hull stern-wheel snag-boat, in response to advertisement dated December 8, 1880, and opened January 27, 1881, by Maj. W. H. H. Benyaurd, Corps of Engineers.

No.	Names of bidders.	Iron hull stern-wheel snag-boat.		Date of delivery.	Remarks.
		Quantity.	Price.		
1	Allen & Blaisdell.....	1	$44,650 00	July 2, 1881	Accepted.

REPORT OF CAPTAIN E. F. WHITE.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 2, 1881.

MAJOR: I respectfully submit the following report of the operations of the United States snag-boat O. G. Wagner, in the Red River.

In compliance with your instructions, I left Red River Landing October 15; proceeded up the Red River and removed the snags and other obstructions in the vicinity of the following points, viz: Mouth of Big Black, Little Larts, the foot of Rapions, Lake Long, Racourci, Nigi Point, the head of the Rapions, Saint James, Barbein's Landing, Weir's Landing, Cottonwood Bayou, Experiment, Snaggy Point, Egg Bend, Stonewall Landing, Wise's Landing, Enterprise, Alexandria, Swilly's Bar, Flagland, Highdi, Grand Ecou, Rosa Bar, Brownsville, Texas Landing, Home Place, Bayou la Chute, Starling's, Morse's, Cotton Point, Irishman's Shanty, Campobello, Robinson's, and Riverdale.

I reached Riverdale December 17, where I received orders to stop work and proceed with the boat to New Orleans, lay her up in charge of two watchmen, and report to you at Memphis.

I beg leave to call your attention specially to the important work accomplished at the following points:

At the Confederate raft below Alexandria the channel was so obstructed with the piling that at low-water it was impossible for steamers to pass through with a barge in tow. I removed these obstructions, making a channel 150 feet wide, thus enabling steamers to pass through with a barge on each side.

At the Rapions, the number of sunken snags rendered this narrow channel dangerous, especially at night; I removed the sunken snags with a sweep-chain, making the passage of steamers at night perfectly safe.

At the falls above Alexandria, I removed a sunken shaft and boiler which had been a source of considerable annoyance to steamboat men for some time, and was exceedingly dangerous to navigation.

I found dangerous obstructions at Snaggy Point, but owing to the sudden rise of the river I was unable to complete their removal, and would most respectfully suggest that this point receive further attention.

The summary of the work accomplished in the Red River is as follows, viz: 665 snags removed, 768 trees cut down, and 448 shore snags destroyed.

It is exceedingly gratifying to me to be able to state that parties engaged in the navigation of the Red River have not only expressed their satisfaction with the operations of the Wagner, but have highly commended her for the large amount of important work accomplished during the season.

In conclusion, I would respectfully call your attention to the river between Cotton Point and Shreveport. Navigation is obstructed by leaning trees and snags projecting from the banks, rendering it dangerous for steamboats.

Very respectfully, your obedient servant,

E. F. WHITE,
Commanding United States Snag-boat O. G. Wagner.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

For the following statistics I am indebted to Charles P. Truslow, president of the Red River Line:

From September 1, 1880, to July 1, 1881, New Orleans received from Red River as follows:

183,000 bales of cotton, valued at.....	$9,150,000
00,000 sacks cotton seed, valued at.....	60,000

5,000 head of cattle, valued at	$100,000
3,000 hogsheads sugar, valued at	300,000
10,000 barrels molasses, valued at	200,000
Grain, hides, and sundries, valued at	75,000
Total	9,885,000

There are about 50,000 tons of general merchandise shipped up Red River annually, the value of which will exceed the down-stream shipments, as a great deal of Texas freights are shipped via Red River.

P 7.

IMPROVEMENT OF UPPER RED RIVER, ARKANSAS, FROM FULTON TO THE HEAD OF THE RAFT.

During the past season the work on Upper Red River consisted in the removal of snags, logs, stumps, &c., between Fulton, Ark., and the head of the raft.

For carrying on the work, the machinery of the old crane-boat belonging to the Red River Raft property was taken to Fulton and placed upon a flat-boat obtained for the purpose. The boat was also properly fitted out with all the tools and outfit necessary for such work, and operations commenced at Fulton on the 1st of September.

The river for the first 70 miles was found to be in a very bad condition; large drift piles had accumulated on the sand-bars, and a number of the bends were blocked up with a mass of timber which had caved in from the banks. The work was continued down to about 4 miles below Spring Bank, 130 miles below Fulton, when the operations had to be suspended on account of high-water. During the time worked, 460 snags were pulled, 1,155 logs removed, 371 stumps taken out, and 190 trees cut down.

The following extract taken from the reports of George Alban, who was in charge of the work, will give the nature of the operations:

After receiving your instructions to take charge of the work on Upper Red River, I proceeded to Fulton, Ark., at which place I arrived on the 14th July. I had ordered the tools and equipments belonging to the Red River raft work to be shipped from Shreveport, and also the crane-boat machinery which was stored at that place, but it did not reach Fulton until the 30th of July. I then hired carpenters and laborers and commenced fitting up the crane machinery. I put all the force at work that I could abtain, and had the boat ready for work on September 1.

We left Fulton, passed through the bridge and commenced operations immediately below. We found the river full of snags and beds of logs, both in the channel and on the sides of the banks. The crane machinery worked well until the 4th of October, when a guy hook gave way while raising a large cotton tree, drawing the mast over the bow of the boat, breaking the casting on the foot of the mast, and the circle ring on the deck. I immediately sent the casting to Little Rock, Ark., and had a new one cast. We lost abont six days in building a new mast and boom for the crane, and in strengthening the guys and other parts of the boat, but in the mean time kept the force at work chopping on the heads of the sand-bars where large drift piles had accumulated.

We found the river below Dooley's Ferry in a very bad condition; some of the bends were a perfect mass of timber which had caved in from the banks, until we reached Chiconini Cut off, which is 70 miles below Fulton.

The river below this point commenced to improve, the banks had been cleared of falling timber, and a less number of snags were found, until we reached the head of Long Prairie, a distance of 35 miles. From this point to Spring Bank, a distance of 20 miles, the river is in a good condition, very few snags, and a clean bank.

When we arrived here the river had risen 9 feet and was still rising, and by the time we had gone 4 miles below Spring Bank the work had to be stopped, as the river was too high for successful operations. Having received orders that as soon as the river rose, to take the boat to Shreveport and lay up, we proceeded to do so, arriving there on the 13th of December, 1880, when the men were paid off and the boat and property laid up in charge of a watchman.

The steamer Florence made an attempt to go to Fulton in April last, but had to return on account of low-water. Another attempt was made in May, and some work was done in the raft region, but after a few days the water commenced to rise and the boat returned to Shreveport.

No appropriation was asked for for the fiscal year ending June 30, 1882, and none will be asked for for the year ending June 30, 1883, as it is considered that with the balance of funds on hand this section of the river can be placed in a good navigable condition when there is sufficient water for boats to run.

This work is not permanent, and as each flood brings in new obstructions, in the near future appropriation will have to be made to keep the river in a navigable condition.

The estimated cost of this improvement was $19,560.

The former appropriations are as follows:

By act approved March 3, 1879	$10,000 00
By act approved June 14, 1880	10,000 00

Money statement.

July 1, 1880, amount available	$14,223 66
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	9,464 32
July 1, 1881, amount available	4,759 34

COMMERCIAL STATISTICS.

The amount of freight shipped to Shreveport from above and below Fulton, Ark., is as follows:

Cotton	bales ..	17,500
Cotton seed	sacks ..	38,000
Merchandise, &c., received from Shreveport	tons ...	3,000

In addition to this a number of bales of cotton were shipped on the steamboat belonging to the Iron Mountain Railroad, from Spring Bank up to Fulton, and from there by rail.

For port of entry and collection district, see report for removing raft in Red River and closing Tones Bayou, Louisiana.

P 8.

IMPROVEMENT OF YAZOO RIVER, MISSISSIPPI.

The snag-boat John R. Meigs was sent into the Yazoo November 1, 1880, for the purpose of removing snags, logs, and other obstructions from the stream. The work was continued until the 1st of December, when operations were suspended on account of high-water. During this time 65 snags were removed, and 468 leaning trees cut down.

The steamer Florence was also engaged for a couple of weeks in October in the Upper Yazoo, working in conjunction with the Meigs; 5 snags and 2 side-jams were removed, and 1,213 leaning trees cut down.

On the 1st of June the Meigs was again sent into the Yazoo to engage in the usual work of removing obstructions. She will be continued in this work until needed by Captain Handbury for work in his district. During the month 180 snags and 3 rack-heaps were removed, and and 513 leaning trees cut down.

With the appropriation of March 3, 1881, it is proposed to continue the work of removing wrecks, snags, and other obstructions from the stream.

The work is not permanent; new obstructions, caused by floods, caving banks, &c., are brought into the stream each year, and which have to be removed in order to improve the navigation.

ESTIMATE.

Eight months expenses of snag-boat, including incidental repairs, at $2,500 per month	$20,000 00

The former appropriations are as follows:

By act approved March 3, 1873 (applied to the removal of eleven wrecks, sunk in the stream during the operations of the war)	$40,000 00
By act approved March 3, 1875	12,000 00
By act approved August 14, 1876	15,000 00
By act approved June 18, 1878	25,000 00
By act approved March 3, 1879	15,000 00
By act approved June 14, 1880	12,000 00
By act approved March 3, 1881	6,000 00

The Yazoo River is in the collection district of Vicksburg, Miss. The port of entry is New Orleans, La.

Money statement.

July 1, 1880, amount available	$12,000 00	
Amount appropriated by act approved March 3, 1881	6,000 00	
		$18,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		13,266 15
July 1, 1881, amount available		4,733 85
Amount that can be profitably expended in fiscal year ending June 30, 1883		20,000 00

COMMERCIAL STATISTICS.

The amount of freight brought out of the Yazoo and Tallahatchee rivers, as per statement furnished by Capt. E. C. Carroll, superintendent of the Yazoo River Packet Company, is as follows:

Cotton brought out by boats belonging to the Yazoo River Packet Company	bales	68,427
Cotton brought out by other boats	do	5,000
Cotton seed brought out by boats belonging to the Yazoo River Packet Company	sacks	30,687
Cotton seed brought out by other boats	do	30,000

A large number of staves, cattle, hogs, &c., are also transported, and in addition there is a corresponding amount in value of return freight, consisting of plantation supplies and general merchandise.

The value of the above products and freight is estimated as follows:

73,427 bales of cotton	$2,937,080 00
60,687 sacks of cotton seed	24,274 80
Cattle, hogs, staves, &c	10,000 00
Return freight	2,971,354 80
Total estimated value of up and down freight	5,942,709 60

P 9.

IMPROVEMENT OF BIG SUNFLOWER RIVER, MISSISSIPPI.

As none of the snag-boats under my charge could be spared, authority was granted me to charter a light-draught steamboat. This was done

and work continued upon the river in the removal of obstructions to navigation and in building dams at the shoal places.

Operations were continued for six months and extended from the mouth of the river to Faisonia, the present head of navigation. During the season 472 snags and logs were removed and over 7,000 trees cut down. Many of the logs were firmly imbedded in the mud and required a considerable amount of power to effect their removal. A number of the shoal places were caused by logs, the removal of which had the effect of deepening the channel.

Wing-dams were built at Callao and Vick's Landing, for the purpose of concentrating the water into a single channel and deepening the water on the bars. Before commencing the work the water over these bars was scarcely 18 inches; at the completion of the work the depth had increased to 3½ feet, with a reasonable expectation that it would be still further increased.

The following extract from the weekly reports of J. J. Barry, in charge of the work, will give in detail the different operations:

July 2.—As the water in the upper river is unusually high for this season of the year, a consequence of the continuous rains during the month of June, it is very difficult to secure a firm hold on many of the sunken logs, which during extreme low-water are serious impediments to navigation. The operations so far have been confined principally to the cutting of the leaning trees along the banks. The river has risen within the past four days about 2 feet; when it falls to or near low-water line I think it would be well to go over the section we have already worked on and remove more logs. Up to the present date I have to report the cutting of 1,700 trees, and removal of 67 logs. The trees are comparatively small, being of an average diameter of about 1 foot. Willow, cottonwood, sycamore, and gum constitute the general growth along the banks, the willow predominating. The majority of the logs removed are gum, varying in diameter from 2 to 4 feet, and in length from 75 to 100 feet. They are found to be firmly imbedded in mud and sand, and their removal calls for heavy capstan power.

July 9.—Since my last report the work has been continued to Shell Ridge, a distance of fifteen miles below Johnsonville, the county seat of Sunflower County. The river has fallen about 18 inches since the 2d instant. It is still too high to permit of the removal of some logs which would be much in the way at a low stage of water. The amount of work done is 320 leaning trees cut and 119 logs removed.

July 16.—The water at this point, Waco, has fallen within the past week about 10 inches. It has risen at Choctaw Landing (just below the head of Little Sunflower), within the same time, fully as much; the backwater from the Mississippi causing the rise in the lower part of the river. Two hundred and twenty trees have been cut and 116 logs removed.

July 24.—During the past week 93 logs have been removed from the channel-way of the river, in the reaches above and below Shell Ridge. The boat will go below this evening to work at cutting leaning timber on the river between Holland's, Choctaw, and Silver Creek Landings. More log-pulling will be necessary in the upper part of the river, when the water shall have gone down 2 or more feet. At the present stage their removal is so nearly impracticable, with one ordinary steamboat apparatus, that I think it an economy of time and labor to move below and cut the leaning timber.

July 31.—Since last report work has been done on the river between Holland's Landing and Choctaw, or head of Little Sunflower; 18 logs removed and about 400 trees cut. On sheet No. 2 the line A—B at head of a chute shows position of a dam which was made by a coal barge and some pecan trees. The water in channel was so shallow that boats had to be pulled through, and the head of chute was closed to increase the depth of channel-way. It is now full 4 feet. The Sunflower reports water at Callao and Vick's Landing very low. These two places need immediate attention. They can be readily improved by close wing-dams, and I would therefore advise that such works be constructed at once.

August 9.—About 40 logs were taken out of the drift below Choctaw, and 170 trees cut, averaging 12 inches in diameter. Wednesday we left Cypress Bend and proceeded to Callao to construct wing-dams, which will keep us busy for about ten days.

August 14.—The dam on the left bank of the river will be 180 feet in length, and the one on the right bank 220 feet. The piles are driven about 6 feet in the bed of the river, which is sand for about 4 feet, and underneath muck; they are driven firmly and will stand. The depth of water on the bar before commencing the dam was 22 inches; it is now by sounding this afternoon 3½ feet over the entire bar.

August 21.—We completed the two wings of the dam at Callao on Tuesday, 17th instant. The depth of the water before their construction was about 22 inches; it has now an average depth of 3½ feet over the entire bar, which is ample for the navigation of any craft now on the river, and the channel will continue to deepen. I thought it best, in order to prevent the water from undermining, to re-enforce the dam with several large loads of willows thickly laid above the work; this, I am sure, will make it permanent, and continually increase the depth of water. On Wednesday we came up to this place (Vick's Landing), a distance of 24 miles from Callao, where there are two bars which obstruct further navigation; in fact our little steamer could not pass over them, the water having only an average depth of 18 inches. I propose to construct two wing-dams from the left bank of the river, each 130 feet in length and about 250 feet apart, which, when completed, will give, I hope, about 4 feet of water over both bars. The logs in the channel must be removed, for they have made the shoals; many of them lie deep in the mud and may give us trouble. Our next work is cutting timber and pulling logs between Vick's Landing and Garvin's Ferry, 12 miles above here, which will take about four days. I then propose to attack the logs and timber at Nelton Bayou Bend, 15 miles below Vick's Landing, which will occupy us for at least two weeks. The Mussel Shoals, of which you spoke to me, and which you then thought might give trouble, have offered no obstruction up to this time, and it is probable they will not during this season on account of the wing-dams, &c., built there last year.

August 28.—We completed the lower wing of the dam at Vick's Landing, upon which we were engaged at time of my last report, but before commencing the second wing, which I had contemplated building 250 feet above, the dam broke, and all our labor was lost. This was in consequence of its being built at too great an angle with the channel to resist the volume of water forcing itself against it. However, we knocked it to pieces and secured the lumber, with which I built another dam on the same side of the river, a little lower down, 135 feet in length; this one is constructed so that it will last. Not wishing to make another requisition for lumber, I concluded that a dam constructed of logs, trees, and brush would serve our purpose very well, for, if it stood at all, it was the best we could make. I therefore built the second dam 300 feet above, in this way, and on the opposite side of the river, which has changed the current back to its old channel, and now gives us a depth of water of 3½ feet over the bars. This depth will continue to increase as the sand washes away, so that in a few weeks we may reasonably expect 5 feet of water where originally there was only 18 inches. We are now engaged in pulling snags and logs between Vick's Landing and Garvin's Ferry, 12 miles above. It is the wish of the Packet Company (and they are most deeply interested) that at present we only work at the most formidable obstructions, as we will not have time before the boating season begins to clear out the river effectually. This I am endeavoring to do, as the lighter work can be done later.

September 7.—The work of pulling logs and cutting the leaning timber has been continued. At least 90 logs were taken out in a distance of about 4 miles, and 400 trees cut down from the points and bends. Owing to recent heavy rains a rise of 2 feet has occurred.

September 20.—The boat has been working below Choctaw Landing, clearing the points and bends of leaning timber; 1,500 trees were cut from Choctaw and a point 9 miles below. The river is at an unusually high stage for this time of the year, which precludes the idea of working on logs and snags, but the present work of the boat is just as beneficial to navigation.

November 7.—The work of cutting the leaning timber along the banks has been continued. The river is too high to work to advantage at pulling logs, and the cutting of the timber will be completed in two or three days, excepting about 6 miles at the head of navigation, and which can only be cut in high water, or at about the present stage. It will take two weeks to do this work, and then if the river does not fall some 5 or 6 feet it will be a waste of time to continue work any longer.

November 30.—I think in ten or twelve days we will be through cutting in this river, as by that time we will have gone over the entire river from the mouth to the head of navigation, which is Faisonia. There will then be nothing to cut but the 76 miles above Faisonia, which cannot be done to advantage with a steamboat. In low-water a boat cannot go there, and in high-water the stumps cannot be cut low enough.

Considerable work still remains to be done, as there are a great many snags and logs that seriously obstruct the navigation of the river. It is proposed during the coming season to continue their removal and to repair and construct wing-dams.

The appropriation of $15,000 asked for for the fiscal year ending June 30, 1883, will be expended in a like manner.

The estimated cost of the improvement of this river was $66,000.

The former appropriations are as follows:

By act approved March 3, 1879	$20,000
By act approved June 14, 1880	8,000
By act approved March 3, 1881	4,000

The navigation of the river above Faisonia is so uncertain that the planters in that section are compelled to haul their cotton and other products to the Mississippi River for shipment, which will all go down the Sunflower as soon as the improvement of the navigation is completed.

Money statement.

July 1, 1880, amount available	$18,388 32	
Amount appropriated by act approved March 3, 1881	4,000 00	
		$22,388 32
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		18,123 83
July 1, 1881, amount available		4,264 49
Amount (estimated) required for completion of existing project		34,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		15,000 00

COMMERCIAL STATISTICS.

There are eighty-two landings on the Sunflower, all of them shipping more or less cotton, cotton seed, and cattle. The river runs through five different counties, and along its banks are a scattering population numbering about 18,000, who claim this river as the outlet for their products, which are shipped to Vicksburg, and from thence reshipped to New Orleans and other markets. The country is fast filling up, the land being plenty and cheap, and considered as fine as any there is in the South.

A weekly line of steamboats navigate the stream as high up as Faisonia, and during the last season the following amount of business was done:

Cotton brought out by the boats belonging to the Yazoo River Packet Company	bales	17,454
Cotton brought out by other boats	do	2,500
Cotton seed brought out by the boats belonging to the Yazoo River Packet Company	sacks	18,820
Cotton seed brought out by other boats	do	18,000
Cattle and hogs	head	1,300

To this should be added a corresponding amount in value of return freight.
The value of the above products and freight is estimated to be as follows:

19,954 bales of cotton	$798,160 00
36,820 sacks of cotton seed	14,728 00
Cattle, hogs, and other products	15,000 00
Return freight	827,888 00
Total up and down freights	1,655,776 00

P 10.

IMPROVEMENT OF TALLAHATCHEE RIVER, MISSISSIPPI.

The act making appropriation for this river provided that a portion of the funds should be expended between Batesville and the mouth of the Coldwater. For this stretch of the river a flat-boat was built and fitted up with the necessary machinery and quarters for the men. The boat was then taken to the mouth of the Coldwater, where work was started,

and continued to Batesville. In addition to some large rafts and drift-piles, 505 snags and 153 logs were removed, and 1,387 trees cut down.

For work on the section below the mouth of the Coldwater, I sent the United States steamer T. B. Florence into the river in August. Work was started at Pecan Point and continued to the junction with the Yazoo. The obstructions in this stretch of river consist mostly of leaning timber; 27 snags and logs were removed, 3,000 trees cut down, and 1,538 were deadened.

The appropriation act of March 3 last provided for a like division of the funds, and it is proposed therefore during the coming season to work on both sections of the river in removing obstructions to navigation.

With the funds asked for for the fiscal year ending June 30, 1883, it is proposed to continue the same character of work.

The estimated cost of the improvement of this river was $40,000.

The former appropriations are as follows:

By act approved March 3, 1879	$6,000
By act approved June 14, 1880	9,000
By act approved March 3, 1881	3,000

For port of entry and collection district, see report for improving Yazoo River, Mississippi.

Money statement.

July 1, 1880, amount available (appropriation of March 3, 1879)	$1,823 00
July 1, 1881, amount expended during the fiscal year	1,823 00

	Total.	Applied below Coldwater.	Applied between mouth of Coldwater and Batesville.
July 1, 1880, amount available (appropriation of June 14, 1880)	$9,000 00	$4,000 00	$5,000 00
Amount appropriated by act approved March 3, 1881	3,000 00	1,000 00	2,000 00
	12,000 00	5,000 00	7,000 00
uly 1, 1881, amount expended during the fiscal year	10,420 22	3,854 95	6,565 27
July 1, 1881, amount available	1,579 78	1,145 05	434 73

Amount (estimated) required for completion of existing project	$22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	6,000 00

COMMERCIAL STATISTICS.

Cotton is the principal production along the shore of the Tallahatchee River, the outlet for which is through the Tallahatchee to the Yazoo and from thence to Vicksburg. There are a number of prosperous little towns scattered along its banks, and the country is moderately well settled, there is also considerable waste land that will probably become settled as soon as the river is improved so as to afford safe transportation for their products.

During the cotton season two steamboats make weekly trips as high up as Sharkey's Landing, but during the summer season there is but one steamboat per week.

The number of bales of cotton and sacks of cotton seed brought out of the Tallahatchee last season is combined with that of the Yazoo, and will be found in that report.

In addition to the amount brought down the river there is about the same in valne of return freight

P 11.

IMPROVEMENT OF COLDWATER RIVER, MISSISSIPPI.

For the work in this river last season a flat-boat was chartered, having upon it the necessary machinery and outfit for removing obstructions to navigation. Operations were commenced in September, and continued until December 31, 1880. The river was well worked over from the mouth as high up as Neal's Landing, a point 13 miles above the present head of navigation.

The following is a summary of the work done: 296 logs pulled out 132 snags removed, 8 stumps removed, 1,142 trees cut down, 1,198 trees deadened, 778 trees trimmed and topped, 4 rafts cut out, 41 rack-heaps destroyed, 7 draft-piles destroyed.

In addition to the above a blockade of logs and trees, which had been an obstruction for many years, was broken up and destroyed. It was 400 feet long and contained over 500 logs and trees.

No appropriation was asked for last year, and none will be asked for this year, as the nature of the Coldwater is such that boats could not navigate it with safety without the expenditure of a large amount of money, which I do not deem the commerce of the country would warrant at the present time. The upper portion of the river is obstructed for several miles by solid jams from one-quarter to one-half of a mile in length, resembling those on Red River above Shreveport, La., before their removal; and the navigable portion of the stream runs through a thinly settled country, a large portion of the land being covered with heavy cane and timber.

It is proposed during the coming season to expend the balance of the funds on hand in operating on the lower or navigable portion of the river.

The former appropriations are as follows:

By act approved March 3, 1779	$7,000
By act approved June 14, 1880	4,000

For port of entry and collection district, see report for improving Yazoo River, Mississippi.

Money statement.

July 1, 1880, amount available	$8,781	95
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	6,617	75
July 1, 1881, amount available	2,164	20

COMMERCIAL STATISTICS.

The navigable portion of the Coldwater (which extends up as high as Belen, 25 miles above its mouth) runs through a thinly settled country, a large portion of the land being covered with heavy cane and timber. But little business is done on the river, though this portion of it is navigable for about six months of the year.

Above Belen there is plenty of good land, though the country is but poorly settled, as all means of transportation are so difficult. In this section from 1,200 to 1,500 bales of cotton are raised annually, which are sent by wagons to the railroad stations and shipped to New Orleans,

P 12.

IMPROVEMENT OF TCHULA LAKE, MISSISSIPPI.

No work has heretofore been done upon this improvement.

With the appropriation of $3,000, made by act of Congress approved March 3, 1881, it is proposed to improve the navigation, by the removal of the obstructions from the bed and banks of the stream, and with the appropriation asked for for the fiscal year ending June 30, 1883, work will be carried on to the same intent.

The total estimated cost of the work was	$10,000
Appropriated by act approved March 3, 1881	3,000

Money statement.

Amount appropriated by act approved March 3, 1881	$3,000	00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	295	98
July 1, 1881, amount available	2,704	02
Amount (estimated) required for completion of existing project	7,000	00
Amount that can be profitably expended in fiscal year ending June 30, 1883	5,000	00

COMMERCIAL STATISTICS.

The country along the river is highly cultivated, and very productive plantations join one another. The amount of cotton raised is estimated at about 20,000 bales, about one-half of which is brought out through the lake when there is sufficient water for navigation, and the remainder is hauled to the Yazoo, where there is navigation all the year round. When the navigation of the lake is improved so as to admit boats of a light draught to enter earlier in the season, no doubt the greater portion of the crop will come out by that channel.

P 13.

IMPROVEMENT OF YALLABUSHA RIVER, MISSISSIPPI.

No work has heretofore been done upon this improvement.

With the appropriation of March 3, 1881, it is proposed to build a flat-boat for the outfit, and with a hired force engage in the work of removing obstructions from the bed and banks of the stream. To this end a party was sent to the river early in June, and completed the building of the flat-boat, and procured the necessary outfit for the commencement of the work.

With the appropriation asked for, for the fiscal year ending June 30, 1883, it is proposed to continue the work of removing the obstructions.

The estimated cost of this work was	$7,000
Appropriated March 3, 1881	3,500

Money statement.

Amount appropriated by act approved March 3, 1881	$3,500	00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,072	31
July 1, 1881, amount available	2,427	69
Amount (estimated) required for completion of existing project	3,500	00
Amount that can be profitably expended in fiscal year ending June 30, 1883	3,500	00

COMMERCIAL STATISTICS.

Grenada is the principal shipping point, from which place, annually, the amount of cotton shipped is estimated at 12,000 bales. The greater portion of this finds its way by rail to New Orleans. The shipments by river amount to about 3,500 bales each season. After the completion of the improvement, no doubt the greater portion of that which now goes by rail will find its way out by boat, and at reduced rates of freight.

P 14.

IMPROVEMENT OF BIG HATCHIE RIVER, TENNESSEE.

The work upon this stream was commenced in August and continued until December 10, 1880. For the necessary operations a boat was fitted out with quarters for the men, and after the outfit and tools were procured, a party was organized and the work was started at Bolivar, and continued down stream to the mouth of the river. This party was in charge of Capt. P. C. Montgomery.

The upper portion of the river, from Bolivar down to Brownsville, Tenn., a distance of 93 miles, was found to be in an almost unnavigable condition, from the fact that no steamboats had been above the latter place since 1866, as the navigation above that point had been completely cut off by the Louisville and Nashville Railroad Bridge, which was constructed of fixed spans. One of the latter was changed to a draw span in the winter of 1879–'80, which opened up the river above to navigation.

From Brownsville to Morgan's Ferry, a distance of 83 miles, the navigation was greatly obstructed by snags and logs in addition to the leaning timber.

From Morgan's Ferry to the mouth, the main obstructions were the leaning trees, though a few snags were found.

The following is a summary of the work done: 376 snags were removed, 2409 logs taken out, 16,243 trees cut down, 5,710 trees deadened.

A party will be organized, boats will be built, and preparations made for resuming work on the 1st of July.

During the coming season it is proposed to continue the work of removing the snags and logs from the bed of the river, and cutting down the leaning timber along the banks.

The original estimate for the improvement of this river was $30,000.

The appropriation of $10,000 asked for, for the fiscal year ending June 30, 1883, will be expended in operating to the same end.

The former appropriations are as follows:

By act approved June 14, 1880	$10,000
By act approved March 3, 1881	3,500

For collection district and port of entry, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	3,500 00	
		$13,500 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		7,323 46
July 1, 1881, amount available		6,176 54
Amount (estimated) required for completion of existing project		16,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		10,000 00

COMMERCIAL STATISTICS.

The Hatchie River runs through a section of country well settled, and under a good state of cultivation; the principal products are cotton and corn; large numbers of cattle and other stock are also raised.

The amount of freight by river last season was comparatively small, as the insurance companies would take no risks excepting at very high premiums.

The following is the amount of the up and down freight last season:

Bales of cotton	1,350
Sacks of cotton seed	1,500
Tons of sundries	54
Tons of up freight	250
Feet of lumber	60,000

After the river is fully improved, so that steamboats can navigate the stream with safety, all the products of the country will be brought out by river. This is estimated to be as follows:

Bales of cotton	10,000
Sacks of cotton seed	30,000
Feet of lumber	150,000
Staves	250,000

P. 15.

IMPROVEMENT OF OUACHITA RIVER, ARKANSAS AND LOUISIANA.

After certain repairs had been made upon the snag-boat Wagner, incident to her previous season's work, she was sent in August to the Ouachita River, and entered upon her usual work of removing wrecks, snags, and other obstructions to navigation.

During the period engaged, 326 snags were removed and 224 trees cut down. For details of the operations, and locations at which work was carried on, I beg leave to refer to the report of Capt. E. F. White, herewith.

In June the Wagner was again sent to the Upper Ouachita to work from Camden, Ark., down. During this month 130 snags were removed and 3,935 trees cut down.

In addition to the snagging operations, work was also carried on at the lower portion of Catahoula Shoals. At extreme low-water this was usually the highest point reached by boats, and if it were improved so as boats could pass, navigation could be carried on as high as Columbia at all stages. A dam had been built here by the State engineers of Louisiana previous to the war, but certain breaks had occurred in it which destroyed its utility. The break through the middle had become the main steamboat channel, and it was decided to so retain it, and work was carried on to that intent. Part of the old dam was raised and strengthened and two dikes ran out from the east and west shores. A buoy was placed at the end of the west dike as a guide to pilots when the water was over the dam, and additional aid was given by having the banks cleared of all timber and guide poles erected.

Some 80 feet of the old dam still remains to be raised to a proper height, and a guide-wall of 100 feet in length is to be built on the upper line of the chute between the east and west wings. Sufficient stone for this purpose is on the ground, left over from last season's work. The total amount of rock placed in the dams was 7,225 cubic yards. The dam was not raised to its projected height, as the funds appropriated were just about sufficient to give a good line of dikes from each shore.

The work accomplished has had the effect of concentrating the water in a single channel and giving increased depth, sufficient for low-water navigation.

For details of the work at Catahoula Shoals reference is called to the report of W. C. Melvin, assistant engineer, herewith.

The work on the upper crossing still remains to be done. This, when finished, will allow boats to reach Columbia, 60 miles above.

Above this latter point is another obstruction known as Rutland's Bar, which, if improved, will still further increase the navigable length of the river at low-water. It was intended to have had a survey made of this obstruction last year after the completion of the Catahoula work, but high-water prevented. It will be made this season and estimates presented for its improvement.

During the coming season it is intended to continue work at Catahoula, and also to continue work with the snag-boat Wagner.

The appropriation asked for, for the year ending June 30, 1883, will be expended in continuing work with the Wagner, and in operations at Catahoula Shoals.

No detailed estimates will be presented for the improvement of the Ouachita with the snag-boat, since the nature of the work must be continuous from year to year, owing to the character of the obstructions which each flood brings down.

The former appropriations are as follows:

By act approved March 3, 1871	$51,000
By act approved June 10, 1872	100,000
By act approved March 3, 1873	60,000
By act approved August 14, 1876	12,000
By act approved June 18, 1878	10,000
By act approved March 3, 1879	10,000
By act approved June 14, 1880	8,000
By act approved March 3, 1881	12,000

The first appropriations were made with a view to the improvement of the river by means of a system of locks and dams, the estimated cost of which was $1,163,083.75, and by operating with a non-propelling crane-boat. A portion of the funds appropriated had been expended under this project for material, surveys, &c., when it was abandoned, and the balance of the funds were expended in the purchase of an iron-hull snag-boat and in operating it upon the river.

The Ouachita is in the collection district of Arkansas, there being but one, and in the third collection district of Louisiana.

Money statement.

July 1, 1880, amount available	$14,130 84	
Amount appropriated by act approved March 3, 1881	12,000 00	
		$26,130 84
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		18,547 95
July 1, 1881, amount available		7,582 89
Amount that can be profitably expended in fiscal year ending June 30, 1883		25,000 00

REPORT OF CAPTAIN E. F. WHITE.

MEMPHIS, TENN., *January* 2, 1881.

MAJOR: I most respectfully submit the following report on the operations of the United States snag-boat O. G. Wagner, in the Ouachita River, from September 3 to October 15, 1880.

Upon receiving your appointment of August 10 as commanding officer of the Wagner I proceeded to Saint Louis, Mo., where she was then lying, and attended to the completion of the repairs already commenced.

These repairs were completed August 19, and I then, in pursuance of your orders, proceeded with the boat to Memphis, Tenn., where I arrived August 22, and on the next day received instructions to proceed to the Ouachita River, to remove snags and other obstructions below Monroe, La.

I reached Red River Landing August 30, where I expected to meet my Ouachita River pilot, but found that he had returned to his home on account of sickness. It was therefore necessary to go on to Bayou Sara, La., from which place I telegraphed to Capt. F. A. Blanks, president of the New Orleans and Ouachita River Transportation Company, to send me a pilot from New Orleans. The pilot having arrived, I returned to the Ouachita River, and commenced work September 3 at Pattent's Point.

As the time allotted to the Ouachita was short, after consultation with Capt. F. A. Blanks, and also with my pilot, I concluded that more work could be accomplished by working up stream, and removing the snags and other obstructions in the worst places. I requested the steamboat men to report to me any obstructions that they considered necessary to remove during the season, and several were reported which I removed.

I found the bend above Noble's Landing full of sunken logs and driftwood, in consequence of which the channel was entirely unnavigable. I spent two days at this point, cleared the banks of leaning trees, removed the snags and driftwood, and dragged the bottom for sunken logs, leaving the channel in a safe and navigable condition for all steamers running upon this river.

On my way up the river I noticed that in the vicinity of Catahoula Shoals there were a number of dangerous obstructions, and I determined to reserve two weeks to be devoted to work in that locality on my return down stream.

Operations were carried on up stream until September 13, at which date I reached Monroe, La., and on the next day I returned down the river and removed a number of obstructions in the vicinity of the following places, viz: Chimera Reach, Dunn's Landing, Faulk's Landing, Cuba, Columbia, China Grove, Long Lake Landing, Catahoula Shoals, Knight's Landing, Bayou Louis, Alligator Landing, Harrisonburg, Big Orchard, Trinity, Fairplay, and the mouth of Black River.

During the time engaged on the Ouachita River I removed 326 snags, and cut down 224 trees.

I respectfully call your attention to the following wrecks, which are obstructions to navigation in this river:

Wharf-boat at Monroe, La.; said to be the property of Jacob Klein, of Trenton, La.

Steamer Dr. Batey; owner unknown.

Steamer Success, below Rutland's Bar; said to be the property of Capt. George W. Rhea.

Very respectfully, your obedient servant,

E. F. WHITE,
Commanding United States Snag-boat O. G. Wagner.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

REPORT OF MR. W. C. MELVIN, ASSISTANT ENGINEER.

MEMPHIS, TENN., *December* 31, 1880.

MAJOR: I have the honor to submit the following report of the work at Catahoula Shoals, near Harrisonburg on the Ouachita River, during the season of 1880.

The operations were confined to making additions and repairs to the State dam, constructed by authority of the State of Louisiana some time between 1858 and 1860.

This work consisted of an irregular line of stone breakwater, standing 300 feet below the upper bar of the shoals, running down stream, bearing from the east bank toward the west nearly 1,700 feet, the lower end of the line approaching the west bank, leaving an opening of 130 feet intervening for the passage of the water. The width of the river during low-water is about 500 feet.

Several breaks had occurred through this breakwater, and the one near the center became the principal channel. The original channel created by the old dam filled up with gravel and sand deposited below and formed a bar extending down stream fully half a mile down the west shore, forming a middle ground with numerous small outlets through it, which at low-water did not afford a depth of 1 foot.

On the east shore a good depth of water was to be found at all times, from a point 400 feet above the foot of the dam down to Bayou Louis Bar, a little over 1 mile below.

After the break in the dam had assumed the character of main channel a good depth of water was to be found up to 100 feet below this break, and the object of the work of the season just closed was to secure an increased depth through this break and force the whole body of water to follow the east shore. For this purpose a dam was

constructed from the west bank, leaving the shore line at an angle of 35°, and crossing the old dam at the lower line of the break, continuing the wall 110 feet below it, with a deflection down stream of about 2°. The length of this wing is 663 feet; the mean area of the section is about 172 feet, and contains nearly 4,225 cubic yards of stone in the wall; and in the west channel is a stone riprap, or floor, 40 feet by 170 feet, and contains nearly 300 cubic yards of stone. The slope of this wall is on the upstream face, 5 feet perpendicular to 6 horizontal, the back slope 2½ horizontal to 1 perpendicular, the crown raised in the center. At the east end of this dam is placed a can buoy made of light boiler iron one-eighth inch thickness, made air and water tight by rivets and tamping the edges at the joints. This is connected with a mushroom anchor, of 300 pounds weight, by a chain 13 feet in length, and is designed as a warning to pilots to keep in the east channel, the water over the dam being 7 feet when it first shows above the surface.

The east wing of the dam is built on a line parallel with the old, without following its curves, starting from the east bank at a point 300 feet below the spur dike at the head of the bar, and 730 feet above the west wing at its junction with the lower line of the break, following this line 550 feet, then curving west to meet and intersect the remains of the old dam. To this point the new line of the east wing is completed, leaving 80 feet of the old dam to be raised and strengthened, and a guide-wall of 100 feet to be built on the upper line of the chute between the east and west wings. Sufficient stone for the purpose has been taken out of the quarries, and put on the bank convenient for loading in barges. The mean cross-section of this wing is 60 feet nearly, and in the wall are a little over 3,000 cubic yards of stone; both slopes are 1 to 1, the crown 11 feet, and mean height 4½ feet; the channel-way through the break is 110 feet wide, and the extreme low-water line (presumably that of 1879) will leave the top of the old dam 10 inches above water.

The effect desired has been obtained by the two wings; that is, a concentration in one channel and scouring on the bottom.

My gauge, as established at the shoals, 0, represented the bottom of water through the break; the lowest water of 1879 corresponded with 2.9 inches; the lowest water of 1880, 4.5½ inches, 1.8½ inches higher than in 1879; the lowest point of this year was reached October 27. The sinking of the steamer Little Bob B. across the east channel had the effect of checking the fall above the dam, while it increased it below.

Soundings made through the chute on the 25th and repeated on the 26th October show a depth of water 6.4 inches in the chute, and increasing all the way down to the deep water below the bar, while above, it gradually diminishes to the head of the bar to 4 feet, 100 feet above this only 3 feet, and at 150 yards 2½ feet could be found. Pilots complain of this crossing, as they call it, for the reason that it does not remain in the same place. On a falling river the crossing is at the head of what pilots call the "deep hole," commencing at Rock Bar and following the east shore down to the spur dike, or at the head of the dam, where it abruptly terminates. As the water approaches the low-water line this channel moves down, and at the low-water is at the foot of the "deep hole." This upper crossing is frequently closed after a few hours' rain by the sand and gravel brought down from Big and Little Creeks and deposited as soon as it reaches deep water. Pilots favor a crossing above the "deep hole," but from the uncertainties mentioned I think the only permanent low-water channel must be near the lower end of the deep hole.

If at the upper end the scour along the west shore must be forced all the way down to the point opposite the head of the bar on which we have built the dam, or to the extreme low-water crossing (the maps made in 1879 of this show these points). This middle bar between the deep water on the east side of the river and the shoal water on the west forms one of the main obstacles of the shoals and can be easily remedied. A line of breakwater commenced at the west bank opposite the Rock Bar and ending at the foot of the deep hole would be 1,300 feet in length and the mean cross-section not more than 21 feet on the west wing; for the east wing it will be in length 375 feet, cross-section of 31 feet; the material (if stone is used for its construction) is to be had within 500 yards of the work; the amount required, about 1,500 cubic yards.

On the 16th July I received your instructions to proceed to Catahoula Shoals and commence the work described.

An outfit of tools suited for the kind of work required was first obtained, and with the outfit and necessary force of laborers I landed at Pearce's Landing on the evening of the 30th and set to work preparing a temporary camp for shelter. I made an examination and soundings on the shoals, finding 23½ feet depth of water in the channel through the break in the State dam and 18 feet over the dam itself.

Work was not fairly started in the quarries until August 2, when the force got fairly under way at the several places selected for opening pits to obtain stone. I also started a gang of five men cutting brush near the mouth of Big Creek, about 1 mile above the work; another gang of three to clear the camping site.

Work in the quarries continued until September 5, when the water had receded to 7.7 inches on the gauge (0 being the top surface of ground in the break). I began to

move stone in the barges from the upper quarry at the mouth of Little Creek to the west wing of the dam, this being a new line of wall closing the west channel, starting from the west bank on a line running 35° east of the shore line and crossing the old dam at the lower line of the break, then continuing with a slight deflection from the same line down stream 110 feet from the old dam, bearing toward the east shore. On the 8th the water commenced to rise and continued to do so until the 23d, when it reached 12.11 inches on the gauge. With this depth of water I had some trouble in holding the barges in the proper place to unload. I had a line running from one shore to the other, and the line of the wall marked with floating buoys, but every steamer passing up or down the line had to be be sunk to allow her to pass over it; then she would invariably pick up with her wheel a buoy or two. I continued to put down the stone, however, and on the 26th of October the water had receded to 4.5½ inches on the gauge, and the dam had stone enough on it to complete it to the point where I proposed placing a warning buoy that would indicate to pilots that they could not pass over the dam, but to keep the east channel until it was passed.

I had started to work on the east wing of the dam on the 8th of October, with the water 12½ feet on the gauge, building scaffolds along the line, and wheeling stone from the bank and dumping on the line from the scaffolding. On account of the depth of water I had to work in, I did not follow the line of the old dam with its curves and irregularities, but adopted a line direct from the starting point to the point of the old dam above the break. This placed the new line about 15 feet back of the old dam, crossing it at two of the irregular curves.

On the 18th October the water had fallen to 5.10 inches on the gauge, leaving the stone in both lines of dam nearly 4 feet above the water. I then commenced to trim down and regulate the slopes and crown of the work. The west line was trimmed to 6.8 inches on the gauge, with crown of 13 feet, the front slope being 6 horizontal to 5 perpendicular, the rear slope 2½ horizontal to 1 perpendicular, the mean base about 38 feet. The east wing has both slopes 5 to 6, with crown 11 feet, mean base of 26 feet. Both wings have the face and crown smoothly trimmed down, the cavities between the stone filled with small stone, broken and made compact by hammering with sledge-hammers.

On the 25th of October I took soundings through the channel, commencing at the head of the bar, and following down to the deep water below the foot of the old dam, the gauge reading at the time 4.8 inches. At the head of the bar I found 5 feet, gradually increasing to 6½ feet in the chute between the east and west wings; below this was a still greater increase in depth. The greater increase in the scour must be in part attributed to the sunken steamer Little Bob B., which sunk 300 feet below the mouth of the chute on Sunday, 24th. Although her sinking did not change the effect immediately in the chute, it did cause a greater scour to take place near where she lay in the water. On the 26th, when the water was at its lowest (4.5½), the water in the chute was 6.4 inches deep, with increasing depth all the way down to the bow of the wreck, where it was 7.9. Soundings also showed a heavy deposit of sand below the west wing; not more than 3 feet could be found in the old west channel 100 feet below, and the stone floor or riprap was quite covered with this deposit. On the west shore the water has formed eddies in both the upper and lower corners, that on the upper side extending out from the shore about 60 feet; that on the lower side is much greater, extending nearly to the old dam. A difference in water level at the shore line of 7 inches is found, that below the dam being 7 inches below that above. The velocity of movement through the chute at this time was fully equal to 9 miles per hour.

For the purpose of affording to pilots and others a sure guide in passing this dam I had both banks cleared of all trees and undergrowth that could in any way impede a view of the guiding marks placed on the banks for that purpose. On the east bank I left standing a willow tree 2 feet in diameter, the trunk trimmed of its branches 30 feet from the ground. On it I placed a board sign 2 feet wide and 12 feet long, securely fastened to the body of the tree above high-water line. This board is divided in quarters, the corners painted alternately white and black. The tree stands 15 feet above the center line of the channel, between the two wings of the dam. On the top of the bank is placed firmly in the ground, and standing 7 feet above it, posts surmounted by barrels painted black at both ends and white centers. These barrels mark the width of the channel between the walls; a barrel set on a tripod between these two marks the center line of the channel; this barrel is painted with black center and white ends.

On the west bank is an oak tree treated in the same manner as the willow on the east bank, and having secured to the trunk a similar sign board. The posts and painted barrels are also repeated on the west bank, so that while the water covers the stone dam pilots and navigators cannot be at a loss to find the locality of the channel with the trees marking the center, the posts and barrels marking the upper and lower limits and a black floating buoy to mark the end of the west wing.

In submitting the foregoing report of operations on the work placed under my charge

I have not thought it necessary to give in detail the manner of working, other than is sufficient to inform you of what has been done and what is yet to be done to complete this part of the improvement of these shoals. What has been done has effected the purpose that was intended by it, that is, giving an increased depth of water over this bar. What is yet to be done is intended to add stability to it, and give increased facilities to navigators.

Very respectfully,

W. C. MELVIN,
Assistant Engineer.

Maj. W. H. H. BENYAURD.
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The vast importance of the Ouachita River as a commercial highway and means of communication with the markets, for cotton, cotton seed, stock, staves, and other productions of the people of Northern Louisiana and Southern Arkansas, who, not having any railroad facilities, depend entirely on the water transit afforded them by this river and its tributaries, is shown by the following statistics:

The number of boats engaged in navigating this stream during the nine months ending June 1, 1881, was 9 steamers of the two regular lines and 17 independent steamers, including the connecting boats on the tributaries, carrying during that time the following amounts of up and down freight:

DOWN FREIGHT.

144,478 bales cotton, valued at	$7,223,900 00
480 sacks cotton, valued at	9,600 00
228,315 sacks cotton seed, valued at	159,820 50
1,890 sacks seed cotton, valued at	9,450 00
553 hogsheads sugar, valued at	52,535 00
834 barrels molasses, valued at	13,344 00
2,139 head cattle, valued at	42,780 00
5,232 head hogs, valued at	31,382 00
685 head sheep, valued at	2,740 00
1,090 bales hay, valued at	5,450 00
101,196 bales oak staves, valued at	101,196 00
Miscellaneous freight, including hides, wool, tallow, lumber, moss, and country produce	40,000 00
Total down freight	7,692,197 50

UP FREIGHT.

Consisting of provisions, supplies, agricultural implements, and general merchandise.

Shipped from New Orleans 42,679 tons, valued at	$4,267,909 00
Shipped from Saint Louis, and reshipped at mouth of Red River, 1,100 tons, valued at	110,000 00
Total up freight	4,377,900 00
Total down freight	7,692,197 50
Total up freight	4,377,900 00
Total up and down freight	12,070,097 50

Steamboat statement.

Name.	Number of boats.	Tonnage.	Number of trips.	Number of passengers carried.
Ouachita Valley Transportation Company	4	2,130	47	940
Camden Packet Company	5	2,029	58	1,160
Independent boats	17	1,822	.....	1,200
Total	26	5,981	.....	3,300

Tonnage of largest boat in the trade	1,200.84
Tonnage of smallest boat in the trade	180.37
Tonnage running during high-water	5,200
Tonnage running during low-water	1,300

Statement showing reduction of insurance since the improvement in navigation.

Limits.	Previous rate.	Present. rate.	Amount reduced.
Below Harrisonburg	[illegible]	[illegible]	[illegible]
Above Harrisonburg and below Trenton	[illegible]	[illegible]	[illegible]
Above Trenton and below Alabama Landing	1	[illegible]	[illegible]
Above Alabama Landing and below Camden	1¼	[illegible]	[illegible]
Above Camden and below Arkadelphia	2	1	[illegible]
Above Arkadelphia	2¾	2¼	[illegible]

Average reduction 21 per cent.

P 16.

IMPROVEMENT OF BAYOU BARTHOLOMEW, LOUISIANA AND ARKANSAS.

No work has heretofore been done upon this improvement.

With the appropriation of $8,000 made by act of Congress approved March 3, 1881, it is proposed to build a flat-boat, and put thereon the necessary machinery for removing obstructions. Work will be commenced at the bridge crossing of the Mississippi and Texas Railroad, and continued down stream as far as the available funds will permit.

With the appropriation asked for for the fiscal year ending June 30, 1883, it is proposed to continue operations in the same way.

The estimated cost of this work was	$26,862
Appropriated March 3, 1881	8,000

Money statement.

Amount appropriated by act approved March 3, 1881	$8,000	00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	142	85
July 1, 1881, amount available	7,857	15
Amount (estimated) required for completion of existing project	18,862	00
Amount that can be profitably expended in fiscal year ending June 30, 1883	10,000	00

COMMERCIAL STATISTICS.

The average products per season are as follows:

Oak staves carried on flat-floats	180,000
Oak staves carried on steamboats	12,000
Cotton, carried on steamboats, bales	40,000
Cotton, carried by rail to Mississippi River	5,500

P 17.

IMPROVEMENT OF TENSAS RIVER, LOUISIANA.

No work has heretofore been done upon this improvement.

The original estimated cost of improving this stream was $23,000, which included the cost of flat-boat and necessary outfit for removing obstructions.

The present appropriation is so small that no such outfit as that con, templated can be secured, as it would absorb the entire sum. It is therefore, proposed to equip a working force with an outfit of saws, axes, &c., and have them engage in the work of removing the worst obstructions to the navigation of the stream.

With the appropriation asked for for the fiscal year ending June 30, 1883, it is proposed to continue the work of removing the obstructions.

The estimated cost was	$23,000
Appropriated March 3, 1881	3,000

Money statement.

Amount appropriated by act approved March 3, 1881	$3,000 00
July 1, 1881, amount available	3,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	10,000 00

COMMERCIAL STATISTICS.

The amount of cotton shipped from the river annually is estimated at 10,000 bales valued at $500,000, in addition to about 70,000 sacks of cotton-seed. To this should be added a corresponding amount of return freight.

P 18.

IMPROVEMENT OF BAYOU BŒUF, LOUISIANA.

No work has heretofore been done upon this improvement.

From Wallace's Landing to the mouth, a distance of 280 miles, the river is obstructed by snags, logs, and overhanging trees, and for the present it is only deemed advisable to improve the navigation by removing these obstructions, which will allow boats to ascend to Wallace's Landing during that portion of the season when the water in the bayou is only sufficient for boats of the lightest draught, and the work will be carried on to this end.

With the appropriation asked for for the fiscal year ending June 30, 1883, it is proposed to continue the work as above.

The estimated cost of this work was	$20,020
Amount appropriated by act approved March 3, 1881	5,000

Money statement.

Amount appropriated by act approved March 3, 1881	$5,000 00
July 1, 1881, amount available	5,000 00
Amount (estimated) required for completion of existing project	15,020 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	8,000 00

COMMERCIAL STATISTICS.

The amount of cotton shipped annually from the bayou is estimated at 17,000 bales, valued at $850,000. From the upper portion of the stream the products find a market in New Orleans, via the Vicksburg and Shreveport Railroad to Delta, La., and from thence down the river by boat. The charge, per bale, to New Orleans by this route is $2.50; by boats directly down the bayou when the stage of water admits, $1.50.

After the improvement of the stream by the removal of the obstructions the annual shipments will be greatly increased.

EXAMINATION OF BŒUF RIVER [BAYOU BŒUF], LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 1, 1880.

GENERAL: I have the honor to submit the following report upon the examination of Bayou Bœuf, Louisiana, in accordance with act of Congress approved June 14, 1880.

The examination was made by Mr. H. St. L. Coppée, assistant engineer, whose report will be found annexed, and was made with a view of determining the character and extent of the obstructions to navigation, with estimated cost of removing same, and the nature and extent of the commerce to be benefited.

The stream was examined from the State line between Arkansas and Louisiana to its junction with the Ouachita, a distance of 346 miles. The upper reach of the river for a distance of 66 miles, that is, from the State line to Wallace's Landing, is made up of numerous small lakes, connected by short stretches of river, which in many places are not over 20 feet in width. This part of the river may be compared more to a swamp, and is so obstructed by snags, logs, stumps, &c., and the commercial advantages to be gained by improving the same, even for high-water navigation, are so small in comparison to the amount required for the work, that it is not deemed advisable to consider this part of the river as desirable to be improved. The land in this section is susceptible of a high degree of cultivation, but the constant liability of destruction of the crops, due to breaks in the Mississippi levees in the State of Arkansas, causes the lands to be abandoned.

From Wallace's Landing to the mouth, a distance of about 280 miles, the river is obstructed by snags, logs, and overhanging timber. For the present it is only deemed advisable to improve the navigation by removing these obstructions, which will allow boats to ascend to Wallace's Landing during that portion of the season when the water in the bayou is only sufficient for boats of the lightest draught.

The amount of cotton shipped annually from the bayou is estimated at 17,000 bales, valued at $850,000, to which must be added return freight, &c., to almost an equal amount. From the upper portion of the stream, the products find a market in New Orleans, via the Vicksburg and Shreveport Railroad, to Delta, and thence down the river by boat. The charge per bale to New Orleans by this route is $2.50; by boats directly down the bayou, when the stage of water admits, $1.50. Were the stream improved by the removal of the obstructions above noticed, the crop of cotton and other products would be greatly increased.

The estimated cost of the work is $20,020.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. ST. COPPÉE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 2, 1880.

MAJOR: In accordance with your instructions, received at Grand Gulf October 8, I removed my party to Vicksburg, where I obtained tents, blankets, &c., for the three examinations—bayous Tensas and Maçon, and the Bœuf River. The Tensas I directed

Mr. H. C. Wilson to examine, Mr. F. S. Burrowes the Maçon, and I, myself, took the Bœuf River, the report of which I have the honor to submit, as follows:

The Bœuf River, which I examined from the State line dividing Louisiana and Arkansas to the mouth, I shall, for convenience of description, divide into two parts: That portion from the line to Wallace's, or the first reach, being closed by logs, rafts, drift, &c., and very difficult to improve for navigation; and a second reach from Wallace's to the mouth, which differs in every respect, having been navigated for some years past at a stage of about 7 feet above low-water.

From what I could gather, I judge the river to be at the time of this examination about 3 feet above low-water mark, *i. e.*, the lowest water known, and falling.

FIRST REACH.

The Bœuf River at the State line is about 20 miles in a direct line from and west of the Mississippi River. The stream 3 miles above the line is in the form of a lake, quite wide and deep enough to float the largest river boats, but at a point half a mile below, called the Shingle House Crossing, it scatters into numerous branches narrow and shallow enough to ford at low-water, and exists in that condition until the Ashton Road Crossing is reached, 4 miles below the State line; thence the stream begins to collect its branches, and where they finally come together there is a raft of logs, drift, &c., probably 1,000 yards through.

From the Ashton Road Crossing the river again takes the form of a lake, averaging 150 feet wide by 13 feet deep by 4 miles long. This lake contains about 30 snags, 15 logs partially and in places entirely across the stream. Should improvements be attempted, 10 overhanging trees would also have to be cut down. The lake is comparatively straight, *i. e.*, the bends are not sharp or narrow. From the foot of the lake for a distance of 8 miles the stream is very crooked, and difficult, at the present stage of water, to navigate even with a skiff. In many places cypress trees stand directly in the channel. The width varies from 20 to 100 feet, and the depth from 9 to 3 feet. Forty logs or fallen trees cross the stream at different intervals, causing rafts and heavy drift piles to form, making it impassable In this stretch I counted 60 snags and 9 large cypress stumps. The shoals (3 feet of water at the present stage) are also very numerous; these shoals are caused by sand-bars forming below the narrow bends. In case of improvement a great number of overhanging trees would have to be cut. From this point, which is 16 miles from the State line, to Wallace's, 50 miles further by river, the stream is a continuation of lakes and narrow bends following each other successively. The lakes, which vary from ¼ to 2 miles in length, have an average depth of 5 feet, width of 100 feet, and but little current.

At the end of each lake there is generally a mile or more of sharp, horseshoe bends, in places the river being not over 20 feet wide by two feet deep, containing sand-bars, rafts, drift piles, trees, and stumps standing in channel, and every few hundred feet a cypress log stretching from bank to bank. Between the lakes or straight open stretches the current is considerably accelerated.

The river in the upper portion of this first reach runs through a swamp, about 4 miles wide, lying between the Maçon hills and the high lands east of bayou Bartholomew, whereas through the lower portion the country is higher, the bank being usually about 17 feet high.

The soil is of a sandy composition, the bank in some places showing thin strata of clay, the surface of the adjacent country being of the same nature; the river bed is generally a hard, compact sand.

The timber throughout the reach varies; that at the upper end being superior in quality and quantity; 1 mile west of the river, at the State line, there is a strip of good pine two miles wide by about 15 miles long, running southeast.

The entire reach contains cypress, many varieties of oak, such as white, cow, black, red, overcup, pin, &c.; hickory, gum, elm, and ash are also found. The timber which principally fringes the river is cypress and oak.

COMMERCIAL STATISTICS.

The land adjacent to the Bœuf, for some distance both above and below the State line, is capable of high cultivation, but owing to the sickliness of the climate and the liability to overflow, it is but little worked. The plantations or clearings east of the Shingle House, on the Maçon hills, are many of them deserted. The planters at present average about 15 bales of cotton apiece. Should this upper portion of the river be opened to navigation, the acreage of cultivated land would be greatly increased. The products of the country west of and in the vicinity of this reach of the Bœuf pretty much all find an outlet by way of the Bartholomew, and probably would do so were the stream made navigable; the products on both sides, from the Shingle House as far south as Wallace's, would amount to about 300 bales of cotton per annum, and

even some of this might be shipped by the Maçon in preference. Most of the produce would come from Oak Grove, on the Maçon hills, and Shilling's neighborhood, near the river; the cattle trade would be but light, owing to the great loss incurred at overflow time.

In my estimation the great outlay necessary to make this 66 miles of river navigable, even at high-water, would hardly be compensated for by the little cotton (300 bales), seed, cattle, &c., that the country would produce.

The unhealthy and present backward condition of this section, in a great degree, is due to overflows; these, from some time before 1842 until after 1864, did not occur, because of the good condition of the levees bordering the Mississippi River, but during the late rebellion these were destroyed in many places, so that since, at every overflow of the Mississippi River, all this country lying between the Ouachita and the Mississippi is inundated, excepting the high ridges, probably 16 feet above high-water mark, such as Maçon hills, &c. The principal breaks necessary to rebuild in order to protect this Bœuf country are in the Matthew's Bend levee, which I am told an 8-foot levee would protect, and the Possum Fork. The Ashton break would affect the Maçon and Tensas, but not the Bœuf, owing to the intervening hills.

The oscillation of the Bœuf is about 30 feet, the time of rising and falling corresponding very nearly with the Mississippi River; the planters look for high-water in December and low-water in the summer and fall.

SECOND REACH.

This reach extends from Wallace's to the mouth of the river. The following table shows the distance in miles from point to point on the stream, the depths, widths, height of banks when not in swamp, the number of snags, leaning trees, and logs necessary to remove should improvement be contemplated. These are all estimated for a stage of water 5 feet above the present.

Table.

From Wallace's to—	Miles.	Width (feet).	Depth (feet).	Height of bank (feet).	Snags.	Leaning trees.	Logs.
Whitaker's	15	250	8 to 20	20	20	20	10
La Fourche	4	200	10 to 20	15	11	11	10
Lone Plumb	4	160	3 to 10	15	19	30	30
Head of Bends	2	125	2 to 11	15	7	26	22
Bristor's	5	120	10	15	14	39	43
Jerden's	10	120	11	15	30	50	50
Edward's	7	110	11	15	18	33	26
Cheek Place	17	100	2 to 11	8 to 15	61	143	50
Girard Bridge	4	100	4	13	19	31	24
Alto	40	100	2 to 10	13 to 22	109	287	40
Copeland's	40	100	2 to 11	.....	106	217	40
Hebert's	40	50 to 200	2 to 11	.....	193	215	40
Three Rivers	42	70 to 200	2 to 11	.....	100	151	15
Mouth	50	100 to 200	2 to 11	.....	110	47	10
Total	280	.....	.....	.....	817	1,300	410

The river throughout this entire reach repeats itself in general features, lakes open, deep, and comparatively straight, followed by crooked, narrow bends, innumerable bars or shoals, with a depth of water varying from 2 to 3 feet. The banks, to within 150 miles of the mouth, are, generally speaking, abrupt and high, varying from 13 to 20 feet. Below in places they take the form of a natural terrace, or run back from the water surface on a gentle slope, again followed by ridges abrupt and often 30 feet high.

The soil also varies from sand to a mixture of sand and soft alluvial deposit. Fifty miles from the mouth, thick inclined strata of blue clay can be seen in the banks, which here become very high, more like bluffs, which immediately at the mouth are in part composed of loose rock. The bed of the stream is clay, gravel, hard sand, and at the mouth rock. The timber near Wallace's is mostly oak and cypress, the latter being used for all building purposes. This timber is found nearly as far down as Hebert's; there the cypress disappears, a great quantity having been cut and rafted down to the Ouachita in former years. The good oak also runs out, nothing remaining but a poor quality of oak, some gum, and willows. From Copeland's down there are numerous

towheads, or willow bars, forming in the middle of the river. These are very often found where tributaries enter the main stream.

The principal tributary, the La Fourche, which has but a narrow mouth, but further west takes more the form of a lake, enters the Bœuf 19 miles below Wallace's; it runs through a swamp between the Bœuf and Ouachita, leaving it again and returning to the Bœuf at Three Rivers, 230 miles below Wallace's. This stream, near Point Jefferson, flows into the Bœuf at low-water, but during the high stages the reverse is the case. There are numerous other creeks and bayous entering the Bœuf on its course to the mouth, none of which would be of importance to navigation. The principal ones are Davis Bayou, which is called Redmouth Bayou, at Redmouth, where it leaves the Bœuf, again coming in under the name of Davis Bayou, 194 miles below Wallace's; Muddy Bayou, 198 miles below Wallace's; Big Creek, 203 miles below Wallace's; Marengo Creek, 230 miles below Wallace's; Turkey Creek, 3 miles above the mouth; Deer Creek, ½ mile above the mouth; and 13 other small creeks or bayous.

PRINCIPAL TOWNS AND COMMERCIAL STATISTICS.

The Bonnidy Creek country, which is adjacent to the river and west of Wallace's and which at present ships all its produce to Point Jefferson, would, in connection with the country on the east and near Wallace's, bring to a landing at that point about 2,000 bales of cotton, some cotton seed, and cattle. Point Jefferson would bring in about 2,000 bales of cotton, also some cotton seed, and cattle, hogs, &c.

Girard, a town on the Shreveport and Texas Railway, situated ½ mile west of the Bœuf, in Richland Parish, has a population of 75, 6 stores, 2 saloons, a post-office, &c. Prairie Marouge and Bastrop ship in part to Girard and thence by rail to New Orleans; also a large tract of rich country south of Girard sends her its produce. This produce in all amounts to about 5,000 bales of cotton, some cotton seed, cattle, hogs, &c.

Alto, 40 miles below Girard, a town containing about 100 inhabitants, 4 stores, 2 saloons, a post-office, &c., supplies a ridge or tract of very productive country situated above the highest water-mark, which at present sends most of its produce to Rayville, thence by rail to New Orleans. Alto, and landings near Redmouth, Charlieville, &c., would gather about 3,000 bales of cotton, some cotton seed, cattle, hogs, &c.

The freight on cotton per bale to New Orleans, via the Shreveport and Texas Railway from Girard and Rayville, is at present $2.50. By steamer, from points between Point Jefferson and the mouth, it is only $1.50. From Charlieville the country, which is well settled and capable of high cultivation on both sides of the river as far as Hebert's and as far as the mouth on the east, would bring to the several landings an aggregate amount of about 5,000 bales of cotton. As a total in this reach I estimate that about 17,000 bales of cotton, some cotton seed, and a small quantity of cattle, hogs, &c., would at once be shipped by river to New Orleans were navigation improved, and in the near future these figures would greatly increase.

The effect of overflow is similar in this lower reach to that above, with the exception that at times the Ouachita River backs its water up the Bœuf probably 50 miles. In 1874, owing to a break having occurred in Morrison's levee on the Ouachita, the current of the Bœuf was checked nearly 200 miles above its mouth, and the lands in the vicinity of Hebert's and above were inundated.

Before coming to the estimate for improvement, I would state that, in my opinion, anything like improvement of the Bœuf River for low-water navigation is out of the question. The shoals, bars, towheads, bends, low-water snags, &c., are far too numerous to be removed without a great expense in the way of dredging, dam and lock building, &c.

The steamer Erie No. 10, commanded by Captain Hamilton, has been running in the Bœuf for the last two years during high-water as far as Point Jefferson, but with difficulty and danger, because of the snags and overhanging trees. These I would suggest removing.

The following estimate of the cost of improvement is for a stage 5 feet above the present water surface, which would make navigation good about 5 months in the year.

ESTIMATE.

Expense for one month:

Engineer in charge	$150
Mate	100
Cook and helper	60
20 men at $40 per month	800
Subsistence, 24 men at 50 cents per day	360
Total	1,470

To improve the river from Wallace's to the mouth, 280 miles:

Flatboat, with necessary tools	$3,500
Removing snags, &c., 10 months' work (2 seasons)	14,700
Contingencies, 10 per cent	1,820
Total	20,020

This work would have to be accomplished during low-water. The boat used should not draw more than 15 inches.

Very respectfully, your obedient servant,

H. ST. L. COPPÉE,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
United States Engineers.

P 19.

IMPROVEMENT OF CYPRESS BAYOU, TEXAS AND LOUISIANA.

A well defined channel for high-water navigation had been cut out and dredged through the lakes and bayou from Red River, Louisiana, to Jefferson, Tex.

It was stated in the report for last year that, should further improvements be desired, it would require extensive works, such as recommended by Major Howell; that project being to construct a dam across the lakes at Albany Point, and make a cut through to Red River, the estimated cost of which was $372,580, and no appropriation was made therefor.

No actual work in the way of improvement was carried on. The property was placed in charge of watchmen, and the dredge-boat was put in good order. As it is a valuable piece of machinery, and could be used for other purposes, it was taken to the mouth of Red River, where operations were carried on in keeping open a dredged channel.

The appropriations are as follows:

By act approved June 10, 1872	$10,000
By act approved March 3, 1873	50,000
By act approved August 14, 1876	13,000
By act approved June 18, 1878	15,000
By act approved March 3, 1879	6,000

Money statement.

July 1, 1880, amount available	$4,349 04
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,539 04
July 1, 1881, amount avilable	2,810 00

P 20.

IMPROVEMENT OF WHITE AND SAINT FRANCIS RIVERS, ARKANSAS.

In July, 1880, the snag-boat John R. Meigs was sent to Saint Louis for repairs incident to the previous season's operations, and to have certain additions made to her machinery.

On September 1, 1880, she was sent into White River for work in the

lower part of the stream. The river was cleared of obstructions from the mouth to De Vall's Bluff, the highest point reached. In the latter part of October, the boat was withdrawn for the purpose of sending her into Yazoo River.

During the time worked, the Meigs removed 270 snags, cut down 298 leaning trees, and removed the wreck of a coal barge at De Vall's Bluff.

As the Meigs was too large a boat to work well on the lower Saint Francis River, I chartered the steamer Mike Davis, and commenced operations the latter part of August, and worked until October 15, when the boat and party were transferred to L'Auguille River.

During the time worked in the Saint Francis River, 81 snags, 107 logs, and 71 stumps were removed from the channel, and 523 trees cut from the banks.

February 7, 1881, this work was transferred to Capt. Thomas H. Handbury, Corps of Engineers, United States Army.

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The former appropriations are as follows.

Allotted from appropriations for contingencies of rivers and harbors (act approved July 11, 1870), for the improvement of White River	$10,000
By act approved March 3, 1871, for the improvement of Saint Francis River, in Arkansas	10,000
By act approved March 3, 1873, for the improvement of White and Saint Francis Rivers	50,000
By act approved June 18, 1878	40,000
By act approved March 3, 1879	12,000
By act approved June 14, 1880	12,000

P 20.

IMPROVEMENT OF WHITE RIVER, BETWEEN JACKSONPORT AND BUFFALO SHOALS, ARKANSAS.

This improvement was commenced under an appropriation of $10,000 "for improving White River at Buffalo Shoals, Arkansas," by Major Suter, in 1877. The plan at this point contemplated the construction of seven spur-dikes of stone, so located as to pond up the water in the places of least depth.

Upon assuming charge of the work in 1879 under the above title, three of these proposed dikes had been completed. During that season the remaining dikes were finished, and, as there remained a balance of the appropriation, work was continued down stream at Nellie's Apron Shoals, 2 miles below, where a large and dangerous ledge of rocks was blasted out, and also at a place known as the Rapids, twenty miles further down, where 2 wing-dams of brush and rock were built.

At the beginning of last season (1880), operations were again resumed. The work was started at Samm's Shoal, 2 miles below Calico Rock. The water was concentrated in a single channel by a dam of brush, rock, and gravel in alternate layers. The dam extended from the foot of Wolf Island to the head of the bar below, a distance of 565 feet.

Upon the completion of this work, the party was moved down to Arnold's Island. The river, here divided by a bar, was concentrated into a single channel by building a brush and gravel dam 200 feet long and 5 feet high at the deepest part, from the island proper to the bar. This construction gave about 5 inches additional water in the channel, with the expectation that much benefit would be derived from the scouring induced.

About 1 mile below, at Maguire's Shoal, a similar dam was constructed on the high gravel-bar on the left bank, and extended into the river some 200 feet. To complete this improvement it may be found necessary to build a down-stream wing-dam or training-wall.

In conjunction with this brush and stone work at the different points, the steamer Winnie was chartered and employed during a short period of the season, removing snags and other obstructions, working over the entire reach of the river, and removing 56 snags and stumps, and cutting down 105 leaning trees. Many obstructions of this character still remain, and like methods must be used in the removal of the same.

The worst shoals between Jacksonport and Batesville are Saffold, Haggletooth, Smith's Chute, Blue Wing, Fatty Bread, Goose Neck, and Black Island, the last two being the most dangerous, and made so on account of stumps, logs, and snags.

In January, 1881, operations were suspended, and on February 7, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers, United States Army.

For the details of the work I beg leave to refer to the report of Mr. J. D. McKown, herewith.

The former appropriations are as follows:

By act approved June 23, 1874, for improving White River above Jacksonport	$50,000
By act approved August 14, 1876, for improving White River at Buffalo Shoals	10,000
By act approved March 3, 1879, for improving White River, Arkansas	10,000
By act approved June 14, 1880, for improving White River between Jacksonport and Buffalo Shoals, Arkansas	5,000

REPORT OF MR. J. D. M'KOWN, ASSISTANT ENGINEER.

MEMPHIS, TENN, *January* 13, 1881.

MAJOR: I have the honor to make the following report of work done on White River, Arkansas, during the season of 1880.

An examination of the river between Forsyth, Mo., and Buffalo Shoals, Arkansas, was made during the month of July, a report of which was duly made.

The work of improvement was then taken up at Samm's Shoal, about 2 miles below Calico Rock. The water at this place was thrown together by building a dam to connect the foot of Wolf Island and the head of the bar below, a distance of 565 feet.

It was fortunate that work was commenced as soon as it was, as the channel was evidently changing and going through between the foot of the island and the bar, which would have been a serious disadvantage, as it would have made a short turn in a narrow chute with a rapid current.

The dam was built of brush, rock, and gravel in alternate layers.

I will here say that I think dams of this kind are preferable to any other for that portion of the river, wherever a good gravel foundation can be had. The loose brush with the butts down stream, and the tops well held down by rock and gravel, or heavy gravel alone, resist the current well. Neither ice nor drift seem to affect it much, as they slide over without injuring it.

After finishing the work at Samm's Shoal, the whole outfit was moved down to that part of the river between Jacksonport and Batesville.

The first work done on this part of the river was at Arnold's Island, which was the shallowest place in the river. The water, which was here divided by a bar, was thrown together by a brush and gravel dam running from the island proper to the bar. This gave about 5 inches more water on the shoal. But the greatest benefit will be from the scouring on the shoal, which must take place. Some little assistance may be necessary, as the gravel is heavy and rather hard.

The dam is 200 feet in length and 5 feet high in the deepest place.

Another dam was built about ½ mile below, at the upper end of Maguire's Shoal. This was started on the high gravel-bar on the left bank, and runs out into the river 200 feet. The current was very strong and the brush had to be held in place by stakes driven in the ground until weighted down by the gravel. It may require a wing, or

training wall, running down stream to be added next season. I noticed before leaving that the bar below, which was very much in the way, was cutting out nicely.

Both dams gave immediate relief, and a good test of the benefit given to navigation is that all the rivermen acknowledge their usefulness.

A large amount of good was also done by removing some snags and stumps, by cutting off overhanging trees, and those which were liable to fall into the stream, to form new obstructions.

There are a number of snags in the river, some of them very dangerous. Great relief would be given to navigation by their removal. During the short time that the steamer Winnie was employed for that purpose, she removed 56 snags and stumps, and 105 trees were cut from the banks.

There are a great many similar obstructions still remaining, which if taken out would render navigation much safer. The low-water season is the only time that this work can be carried on to advantage. At that time there is not sufficient depth of water in the river to allow the use of any of the regular-snag boats to work. A cheap and efficient boat could be built that would answer the purpose, and not cost over $3,000, with all the appurtenances and rigging on board. It would be of such light draught as to enable it to work during extreme low-water.

The past season has been an exceptionally bad one for work. It was almost impossible to get hands at any reasonable price. The winter set in early and severe, when the continued bad weather prevented good work being done.

The bad weather has seriously interferred with the gathering of the cotton crop. A great deal of it is still in the field, and unless the weather is unusually good hereafter, much of it will be lost. At the best there will not be over two-thirds of a crop realized.

The trade of this country is continually increasing, and if the river between Jacksonport and Batesville was in good condition, it would be a great benefit to the country, as the inhabitants are wholly dependent on the river as a means of transportation, the only alternative being hauling by wagon to the railroad.

The worst shoals between Jacksonport and Batesville, and those in need of improvement first, are as follows: Saffold, Haggletooth, Smith's Chute, Blue Wing, and Fatty Bread. But the most dangerous are Goose Neck and Black Island, on account of the stumps, logs, and snags.

Very respectfully, your obedient servant,

J. D. McKown,
Assistant Engineer.

Maj. W. H. H. Benyaurd,
Corps of Engineers, U. S. A.

P 22.

IMPROVEMENT OF WHITE RIVER ABOVE BUFFALO SHOALS, ARKANSAS.

As no work had heretofore been done upon this section of White River, and as but little was known of the character of the obstructions and the nature and extent of the improvements desired, I directed an examination of the river to be made, with a view to presenting a project for the expenditure of the funds. This examination was started at Forsyth, Mo., and extended to Buffalo Shoals, Arkansas, and was under the charge of Mr. J. D. McKown, whose report will be found annexed.

The work showed that improvements were needed at a number of shoal places, which, with the work being carried on below, would, when completed, give navigation to the upper stretches of White River for a considerably longer period of the year. The estimated cost of the work was $32,600. The project approved contemplated starting at the shoals immediately above Buffalo and continuing work up stream to the extent of the available funds.

The lateness of the season after the examination prevented the work being carried into execution.

On the 7th of February, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers.

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REPORT OF MR. J. D. M'KOWN, ASSISTANT ENGINEER.

SAMM'S SHOALS, ARKANSAS,
August 4, 1880.

MAJOR: I have the honor to make the following report of my examination of White River from Forsyth, Mo., and Buffalo Shoals, Arkansas.

Leaving Forsyth on the 15th of July, with the river about 1 foot above low-water and falling, it gave a good opportunity for making the examination.

Although there are a number of gravel shoals on the river, they may all be considered of minor importance, as when the boats can pass the bad shoals after improving them, there will always be water enough to pass the gravel shoals.

The first place of any importance is Conner's Shoal, 6 miles below Forsyth. It is caused by loose rock and bowlders in the bed of the stream, none of which are very large; very little blasting will be necessary. The shoal is about 500 feet long, and will require $800 to improve it.

The next is a similar shoal at the mouth of Big Beaver Creek, 8 miles below Forsyth. The rock can be rolled out by hand at a cost of $500. I have called it No. 2.

Two miles below is a shoal of the same character, but not of so much importance. About $500 will improve it. I have called it No. 3.

At about 11 miles below Forsyth is a long shoal, with a rough, solid rock bottom (No. 4). It will take $2,500 to put it in passable order.

About 1 mile below is a place where the river is divided by an island (No. 5). A short dam should be built at the head of the left-hand chute. At the foot of the island the channel is obstructed by logs and rocks, which should be taken out. The cost would be about $1,000.

At about 15 miles from Forsyth is quite a bad shoal (No. 6). The channel is badly obstructed by loose rock. They could be taken out at a cost of $800.

After this comes a piece of river which, although generally bad, has no shoal of the kind at present taken into consideration.

Then, at 40 miles below Forsyth, there is a very bad place, known as the "Toe of Horseshoe Bend." Nearly all the water runs to the left, making a very sharp turn, having a rapid current running close to the banks, and is obstructed by large bowlders. This could be remedied by throwing the water into the center, or rather to the right of the island, cutting the overhanging timber, and taking out the rock below. The estimated cost is $1,500.

The next bad place is 47 miles below Forsyth, "Elbow Shoal." The main river makes a sharp bend to the left; but some years ago the State of Missouri cut a channel through the bar on the left and threw a dam across the river at the head of the shoal. The top of the dam has washed off so as to allow the greater part of the water to pass over it, and forms a very bad obstruction. The shoal needs improvement, but whether it is advisable to take the dam out altogether, or build it up again, can only be settled by a careful survey of the locality. My opinion is that raising the dam would be advisable, but there are many points to be taken into consideration. The improvement would cost about $2,000.

Tumbling Shoal, 55 miles below Forsyth, is a troublesome place for boats. The river is divided by an island. The main channel is shallow and obstructed by small bowlders. By closing the right-hand chute and clearing the rock from the channel, great help will be given. The estimated cost is $1,000.

Log Chute, 58 miles from Forsyth, is next. The river is divided by an island, the best channel being on the left. A dam of 400 feet will be required to close it, at a cost of $1,000. Just below the foot of this island, where the river comes together, is another one, which requires a dam on the right, at a cost of $600. Some logs and a few rocks to be taken out, with some leaning trees to be cut, will complete the work at a total cost of $2,000.

At the mouth of Big Creek, 68 miles from Forsyth, a bar of loose rock extends across the river, quartering down stream. The shoal is very short, but shallow; the rocks are small enough to be easily handled. A channel could be worked through for about $500.

Bull Bottom Shoal, 71 miles from Forsyth, is about ½ mile long and very rapid. The bed of the stream is covered with loose rock and bowlders; $1,000 will open a channel through it.

Pot Shoal, 76 miles below Forsyth, is a bad obstruction. The water is divided into three chutes, the main opening being to the left, with a gravel bottom, and has only 4 or 5 inches of water on it. The other chutes should be closed, which could be done at an expense of $1,000.

Magar Shoal, at the mouth of Little North Fork, 80 miles from Forsyth, is a long shoal, reaching fully 3,000 feet. It commences at the mouth of Little North Fork, where the river is divided by a small island. The left-hand chute should be closed. The bed of the stream below is covered with loose rock, which should be taken out wide enough to give a good channel. The material taken out should be used to form low, short wing-dams to concentrate the water, as the river is about 800 feet wide; $2,000 will be necessary for this work.

Ninety miles below Forsyth, at Hall's Narrows, the river is divided into three chan nels. The two outside ones should be closed, and rocks, which are small, should be taken out of the middle one. The shoal is about 800 feet long and will need $1,000 to improve it.

One mile below, commence Bull Shoals, which are about 4,000 feet long. Like Magar Shoal, the river is wide. The obstructions are bowlders. A channel should be cleared, and the rocks taken out be used to concentrate the water; $2,500 will probably be sufficient.

Wild Cat Shoal, 104 miles from Forsyth, is a very bad place, extending for about 1,500 feet. The principal obstructions are two ledges that run across the river, which are from 6 inches to 2 feet out of water, with the exception of small openings here and there where the water passes through. A channel will have to be blasted through them. The ledges are narrow, not over 6 feet wide. Below the ledges there are some scattering knobs to come off and some loose rock to be taken out. It is a very bad shoal and will cost at least $3,000 to improve.

Three miles below Wild Cat is Summer Shoal. An island in the river divides the water, and the main or left-hand channel is somewhat obstructed by small bowlders, which should be taken out, and the right-hand channel be closed. The river below, to Magnus Landing, nearly a mile, and may be considered part of the same shoal, is obstructed by some loose rock and bowlders which are very much in the way and should be taken out. The whole cost would not exceed $2,000.

The next shoal below is Redbud, about 4 miles below Summer Shoal. Here again are two channels. The main or left-hand channel has a sharp, narrow ledge running across the head, which is out of water, and which will have to be blasted off. Some loose rock are also to be taken out below. The opening on the right should be closed. After this is done there will be an excellent channel. The cost will be about $2,500.

Crooked Creek Shoal commences about 7 miles below, and continues as a series of shoals for about 2 miles. The river here is in very bad condition, and I consider it one of the worst on the river. In places the stream is 1,000 feet wide, and filled with knobs of the ledge, and loose rock. There is nothing that can be called a channel, and one will have to be made. Considerable blasting will have to be done, using all the material taken out of the bed of the stream to build low, flat wing-dams to throw the water together. Where Crooked Creek comes in, the water is deep, but the channel is obstructed by large bowlders, some of them now out of water. These, I think, can be blasted; the pieces dropped in the deep water surrounding them. I think that $5,000 will be sufficient to place it on a level with Buffalo Shoals; perhaps less money will do it.

The above estimates are made on a very hurried examination, and of course are only approximate. The plans are liable to some changes, but they give a very good idea of the work to be done.

The shoals spoken of are only the worst ones, and the estimates given with the idea of making them passable for a few months in the year by using boats of light draught.

I would respectfully suggest that the improvement commence on the lower part of the river for which the appropriation is made, viz, Crooked Creek Shoal. By doing so it would allow a great deal of cotton to be sent by river which now has to be transported by wagon.

No.	Designation.	Distances from Forsyth.	Cost of improvement.	Character.
		Miles		
1	Conner's Shoal	6	$800 00	Loose rock.
2	Big Beaver Shoal	8	500 00	Loose rock and bowlders.
3	No. 3	10	500 00	Loose rock and bowlders.
4	No. 4	11	2,000 00	Solid rock.
5	No. 5	12	1,000 00	Rocks, logs, and dam.
6	No. 6	15	800 00	Loose rock.
7	Toe of Horseshoe Bend	40	1,500 00	Dam, loose rock, and leaning trees.
8	Elbow Shoal	47	2,000 00	Loose rock and dam.
9	Tumbling Shoal	55	1,000 00	Dam and bowlders.
10	Log Chute	58	2,000 00	Dam, logs, bowlders, leaning trees.
11	Big Creek	68	500 00	Loose rock.
12	Bull Bottom	71	1,000 00	Loose rock and bowlders.
13	Pot Shoal	76	1,000 00	Dams.
14	Magar Shoal	80	2,000 00	Loose rock.
15	Hall's Narrows	90	1,000 00	Dams and loose rock.
16	Bull Shoal	91	2,500 00	Bowlders.
17	Wild Cat Shoal	104	3,000 00	Ledge and bowlders.
18	Summer Shoal	107	2,000 00	Dam and loose rock.
19	Redbud Shoal	111	2,500 00	Dam, ledge, and loose rock.
20	Crooked Creek Shoal	118	5,000 00	Rock, dams, and bowlders.
	Total cost		32,600 00	

I will respectfully state that I have hurried this report as much as possible, but having so much other work to attend to has delayed it somewhat.

I have inclosed herewith sketches of all the places mentioned in the report.

Very respectfully, your obedient servant,

J. D. McKown,
Assistant Engineer.

Maj. W. H. H. Benyaurd,
Corps of Engineers, U. S. A.

P 13.

IMPROVEMENT OF SAINT FRANCIS RIVER BETWEEN WITTSBURG AND LESTER LANDING, ARKANSAS.

This improvement contemplated cutting and marking a channel through the lake region, removing snags and other obstructions from the bed and banks of the stream, from the lower part of the lake to Wittsburg.

A party was organized, and furnished with a flat-boat properly equipped for the necessary work. The work was started at Lester Landing early in August, 1880, and continued until January 15, 1881.

During the period worked, the entire stretch of river between the points indicated was gone over, and 599 stumps, 1,294 trees, and 1,056 logs were removed, and 697 trees deadened.

The work accomplished resulted in giving a comparatively good channel for boats navigating the river. They can now go through to Lester Landing (the only mail station on the lower lake) on a stage of water which heretofore allowed them only to reach Wittsburg.

On the 7th of February, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers.

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The former appropriation was:

By act approved June 14, 1880	$5,000

P 24.

IMPROVEMENT OF L'ANGUILLE RIVER, ARKANSAS.

As the snag-boats were all engaged on the larger and more important streams, I was unable to spare one for work in this stream. I therefore chartered a small steamer, the Mike Davis, that had been working in the Saint Francis, and put her into the L'Anguille for a short season's work. The operations were the same as in the other streams in this section of the country, consisting in the removal of snags, logs, trees, &c., from the bed and banks of the river.

During the time worked, 24 snags, 61 stumps, and 506 logs were removed, and 563 trees cut down.

On February 7, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers, United States Army.

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The former appropriations are as follows:

By act approved June 18, 1878	$10,000 00
By act approved March 3, 1879	5,000 00
By act approved June 14, 1880	2,000 00

P 25.

IMPROVEMENT OF FOURCHE LA FÈVE RIVER, ARKANSAS.

The improvement of this stream was commenced in 1879, under the act of March 3, 1879, appropriating the sum of $10,000. An outfit of three complete barges was hired and the work of building dams, blasting rock, and removing obstructions from the bed and banks of the stream was carried on from the mouth to the vicinity of the town of Perryville.

For continuing the work during the past season the light-draught steamer Red Bluff was chartered and work was commenced early in September, under the charge of Capt. Thomas Metzler. The boat left Little Rock on September 15 and proceeded to the Fourche la Fève. As the river was at or near its lowest stage, some work was required at the shoal places at Turner's Rock, Red Ferry, Mrs. May's, and Holford's, in order to get the boat over, and so reach the upper limits of the work. There is comparatively little water in the river at the extreme low stage, and navigation at that period must necessarily be entirely suspended. It is only during the higher stage that navigation is continuous between Perryville and Little Rock, Ark.

Work was continued until a point 25 miles above Perryville was reached, when it was ordered stopped. During the season 53 snags were removed, 8,181 cuts were made in clearing the banks, 3,508 trees deadened, and 2,200 yards of brush and stone dam were built.

About twenty miles of river yet remains to be improved. It is possible also that a portion of the river below Perryville and above Red Ferry may have to be gone over, as the previous work was not completed.

On the 7th of February, 1881, I transferred the work to Capt. Thomas H. Handbury, Corps of Engineers.

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The original estimate for this improvement was $23,034 50

The former appropriations were:

By act approved March 3, 1879	$10,000 00
By act approved June 14, 1880	4,000 00

P 26.

IMPROVEMENT OF SALINE RIVER, ARKANSAS.

The first appropriation for the improvement of this stream was made by act of June 14, 1880, and the work was commenced in August following.

Mount Elba, a point some 140 miles above the mouth of the Saline, has heretofore been considered the head of navigation, but as boats could always reach this point when there was sufficient water in the Ouachita to enable the boats to navigate the Saline also, it was determined to expend as much of the appropriation as was desirable in improving the Saline above Mount Elba, and open up a stretch of river which would give to the people in that section an outlet for their products. Accordingly work was started at Turtle Bar, about 100 miles above Mount Elba, and continued down stream. This stretch of the river was improved by the removal of snags, logs, and overhanging

trees, and the work was continued to a point some 40 miles below Mount Elba, when high-water caused a suspension of the work for the season.

During the time worked, from August to November, 469 snags and 1,151 logs were removed, and 2,416 trees cut down, besides clearing the bed and banks of other obstructions.

February 22, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers, U. S. A.

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The original estimate for the improvement of this river was	$30,151 00
Amount appropriated by act approved June 14, 1880	7,500 00

P 27.

IMPROVEMENT OF BLACK RIVER, ARKANSAS.

Work upon this improvement was commenced in August last. As contemplated in the project, a light-draught steamer, the John A. Williams, was chartered, and, with a working force, was engaged in the removal of snags, logs, and other obstructions from the bed and banks of the stream. The party worked from the mouth to the bridge crossing of the Saint Louis, Iron Mountain and Southern Railroad. Five hundred and fifty-six snags were removed, and 586 leaning trees cut down.

Another force was engaged in building dams at the shoal places, and in closing up several sloughs and bayous which diverted the water from the main channel of the river. At the Devil's Race-path Shoal a brush dam 850 feet long was built, and at Eagle Nest Shoal two dams, respectively 350 and 150 feet in length, were also built. The parties worked from August until November, when high-water caused a suspension of the work.

On February 22, 1881, the work was transferred to Capt. Thomas H. Handbury, Corps of Engineers.

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The estimated cost of this improvement, including cost of light-draught boat, was	$80,800 00
Appropriated by act approved June 14, 1880	15,000 00

P 28.

WATER GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

Observations were continued at all the gauges during the year.

Repairs were made to those at Carrollton, Red River Landing, Natches, Vicksburg, mouth of White River, Helena, and Florence, and new ones erected at Baton Rouge and Lake Providence.

In conjunction with the Mississippi River Commission, bulletin boards were erected at all the points on the Mississippi, for the purpose of giving to steamboats the stage of the water each morning. The accompanying report will give full information as to the manner in which the boards were made and the purpose they fulfill.

A copy of all the records of all the gauges on the river below Cairo, since 1872, was furnished the Mississippi River Commission, and the

observers now send a copy of their weekly report to the office of the commission.

Hydrographs of all the gauges were made, but retained in the office.

As there existed some discrepancies in regard to recorded high-water marks at various points on the Mississippi, Mr. H. B. Herr was directed to go over the whole subject and revise the tables of high and low water marks and resulting oscillations. This he has done in a very thorough manner, as will be seen from the report herewith. Where changes have been made the authorities are all given.

Copies of the gauge records at all the stations for the year are transmitted.

Money statement.

July 1, 1880, amount available	$6,916 28	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$11,916 28
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,405 18
July 1, 1881, amount available		6,511 10
Amount that can be profitably expended in fiscal year ending June 30, 1883		5,000 00

REPORTS OF MR. H. B. HERR, ASSISTANT ENGINEER.

1.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 6, 1881.

MAJOR: In accordance with your instructions I have had water-gauge bulletins erected at the following stations on the Mississippi River, viz: Cairo, Memphis, Helena, mouth of White River, Lake Providence, Vicksburg, Natchez, Red River Landing, and Baton Rouge.

In all cases the bulletins have been placed conveniently near the water-gauges, above high-water mark, and facing the river. The observers have been directed to adjust the bulletins at 8 a. m. each day, that being the hour the gauges are read.

DESCRIPTION OF BULLETINS.

The bulletin frame is supported upon two square hewn cedar posts 6 by 6 inches by 14 feet, sunk 2½ feet into the ground, standing 4 feet apart, each with a wooden cap on top to protect them from the deteriorating effect of the weather.

The frame itself is made of well-seasoned oak, with four receptacles or panels in front to receive as many plates (to be described hereafter), and two panels in rear, each of which will contain four plates. These latter are for the storage of plates when not in use in the front panels.

To maintain the plates in position four vertical pieces with proper grooves extend across the front of the frame, and three, also properly grooved, are placed in rear. On the bottom rail of the frame are wooden stops upon which the plates rest. A copper capping is worked over the tops of vertical pieces to protect them from the weather and from the wearing incident to the placing of plates in position. As a further protection against cutting by the plates, strips of copper are extended down from the capping about an inch into the grooves.

The interior vertical strips, front and rear, are bolted together, and to the frame between, with 8-inch bolts. Other joints are secured by screws. The frame is let into the front of the posts flush with their faces, and secured at each contact with two screws. The top of frame being on a line with top of posts, brings the bottom about 9½ feet above the ground surface. One foot below bottom of frame a plank 4 feet long is supported by brackets fastened to inner sides of posts. Upon this the adjuster stands in placing the plates in position. This platform is reached by a light ladder, which it is the intention to have removed after each adjustment, so that the platform will be comparatively inaccessible to the public.

Before erecting, the entire frame was well oiled, and the front painted white. Also,

in order that the left-hand panel will show white when a reading less than 10 feet is registered, a light tin sheet was permanently placed in this opening, back of the movable plate, and painted white.

The plates are of No. 20 sheet iron, 24 inches high by 20¾ inches wide, and eleven in number for each bulletin. This number is sufficient to show any reading to the nearest quarter of a foot where the oscillation is less than 55 feet; and also whether the river is rising, falling, or stationary. After being well coated with shellac, to prevent oxidation, the plates received three coats of white paint, upon which the figures and letters were put in solid black. The characters placed on the plates are the numerals from 0 to 9, inclusive, with 1, 2, 3, and 4 repeated, the fractions ¼, ½, and ¾, the minus sign (thus —), and the letters R, F, and S. The latter to denote a rising, falling, or stationary condition of the water. The characters are 22 inches high by 18 inches wide, and can be distinguished by the naked eye at a distance of about one-half a mile. For convenience in finding the plate carrying a particular character desired, each plate has the character it bears painted in small type at its top.

I have the honor to be, very respectfully, your obedient servant,

H. B. HERR,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

2.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 13, 1881.

SIR: I have the honor to submit herewith diagrams* and tables referring to the "gauging of the waters of the Lower Mississippi River and tributaries," and collated from the water-gauge records in this office. Also notes explanatory of the tables and diagrams, their import, and some of the inferences to be drawn therefrom.

Very respectfully, your obedient servant,

H. B. HERR.

Maj. W. H. H. BENYAURD,
United States Engineers.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND TRIBUTARIES.

Under the annual appropriation for the purpose, nineteen water-gauges are maintained at as many different stations on the Mississippi River and its principal tributaries, as comprised in the following list, viz, at—

Alexandria, La., on Red River.
Baton Rouge, La., on Mississippi River.
Cairo, Ill., at junction of Mississippi and Ohio Rivers.
Carrollton, La., on Mississippi River.
Florence, Ala., on Tennessee River.
Fort Leavenworth, Kans., on Missouri River.
Helena, Ark., on Mississippi River.
Jacksonport, Ark., on White River.
Lake Providence, Louisiana, on Mississippi River.
Little Rock, Ark., on Arkansas River.
Louisville (upper), Ky., on Ohio River.
Louisville (lower), Ky., on Ohio River.
Memphis, Tenn., on Mississippi River.
Mouth of White River, Arkansas, on Mississippi River.
Nashville, Tenn., on Cumberland River.
Natchez, Miss., on Mississippi River.
Red River Landing, La., on Mississippi River.
Saint Louis, Mo., on Mississippi River.
Vicksburg, Miss., on Mississippi River.

These were established by Maj. W. E. Merrill, United States Engineers, during the latter part of the year 1871, except that at Carrollton, established January, 1872, and at Nashville, August, 1873.

Regular observations were commenced at each station as soon as the gauge was established, and continued regularly since, so that a complete record of daily readings at all the stations (with a few exceptions) has been obtained from January, 1872, to the present time.

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* Not printed.

The charge of these reading and records was transferred from Major Merrill to Capt. (now Maj.) W. H. H. Benyaurd, United States Engineers, July 29, 1874, and all the records are now on file in this office.

It will be observed that the stations occupy several important points on the Mississippi River at somewhat equal intervals, generally speaking, from Saint Louis to Carrollton; one on each principal tributary (with one exception), and an additional one at Louisville below the canal lock, the other being immediately above the lock. Only a local interest demands a second one at this latter point, but as both gauges are observed by the same observer, no extra expense is incurred in its maintenance.

The tributary excepted above is the Upper Mississippi. A station had been established on this at Rock Island, Ill., and observations were continued there until 1879. The records of that gauge show a comparatively small oscillation, and the high-water periods occurred usually at the time of either a medium or low stage of the main river below Cairo; consequently the water supplied by that portion of this tributary above its junction with the Missouri, has but little effect upon the high-water stages on the Lower Mississippi, and the records at the Rock Island station cannot be regarded as an element of importance in the system of water-gauges here described.

YEARLY MAXIMUM AND MINIMUM STAGES.

In the set of tables immediately to follow, the highest and lowest water readings at each station are given for each year for which reliable authority could be found. Opposite each reading the authority used is given, and where readings have been taken on other gauges, the method of reducing them to the gauges now in use is also stated. All the readings in the tables are referred to the present United States Engineer gauges.

On account of the disappearance of old bench marks a connection is impracticable between the gauges used by Humphreys and Abbot (in their survey of the Mississippi River) and those now established at River Landing and Lake Providence; consequently the tables in these two instances do not extend back to the time of the "Delta survey," as at other stations on the Missiesippi Rivsr.

The sign — placed before a reading in the following tables signifies below zero of the gauge.

ALEXANDRIA GAUGE.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1849	.....	35.4	.....	.....	Maj. W. E. Merrill (Chief of Engineers' Report, 1873, p. 521).
1866	.....	36 5	.....	.....	Do.
1872	Apr. 29	33.3	Dec. 7	−2.6	Maj. W. E. Merrill (water-gauge records).
1873	June 19	30.2	Oct. 1	−0.5	Do.
1874	May 8	34.9	.....	.....	Do.
			Sept. 26	−2.0	Capt. W. H. H. Benyaurd (water-gauge records).
1875	Apr. 27	23.9	Nov. 22	−2.2	Do.
1876	Apr. 17	32.8	Nov. 16	−1.9	Do.
1877	May 18	25.5	Oct. 14	−2.6	Do.
1878	Mar. 13	27.1	Nov. 24	−2.6	Do.
1879	May 26	19.2	Nov. 1	−3.1	Maj. W. H. H. Benyaurd (water-gauge records).
1880	Apr. 11	21.8	Oct. 27	−1.6	Do.

BATON ROUGE GAUGE.

H. and A. stands for Humphreys and Abbot's Report on the Mississippi, edition of 1876.

1828	.....	34.7	.....	.....	H. and A., p. 172, by comparing with 1851.
1844	.....	33 9	.....	.....	Do.
1849	.....	34.9	.....	.....	Do.
1850	.....	34.5	.....	.....	Do.
1851	Mar. 15	34.5	Nov. 24	3.2	Major Merrill (Chief of Engineers' Report, 1874, p. 491).
	Apr. 1				

BATON ROUGE GAUGE—Continued.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1852	June 13	32.0	Oct. 31	3.9	H. and A., p. 524, by adding 1.1, as found by comparing 1851, H. and A., p. 520.
1854	.....	.....	.....	0.2	Major Merrill (Chief of Engineers' Report, 1874, p. 491).
1858	.....	34.5	.....	.....	H. and A., p. 172, by comparing with 1851.
1859	May 6	35.0	.....	.....	Do.
1862	.....	36.1	.....	.....	Major Merrill (Chief of Engineers' Report, 1874, p. 491).
1869	.....	34.5	.....	.....	Do.
1871	.....	34.5	.....	.....	Do.
1872	May 7	29.7	Dec. 22	1.1	Major Merrill (water-gauge records).
1873	June 17	29.9	Jan. 1	2.3	Do.
1874	Apr. 16	36.2	.....	.....	Do.
			Nov. 21	2.3	Captain Benyaurd (water-gauge records).
1875	May 13	29.8	Jan. 1	3.9	Do.
1876	May 8	33.4	Dec. 30	1.7	Do.
1877	June 1	29.7	Jan. 9	0.9	Do.
1878	May 19	29.4	Nov. 6	3.3	Do.
1879	Feb. 15	26.1	Nov. 21	2.0	Major Benyaurd (water-gauge records).
1880	Apr. 22	33.2	Oct. 25	4.0	Do.

CAIRO GAUGE.

1858	June 21	49.6	.....	.....	H. and A., p. 531, by adding 9.2 as per Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1859	May 7	46.5	Nov. 10	5.3	Cairo City water-gauge records, adding 9.2 as above.
1860	Jan. 23	37.2	Oct. 12	3.6	Do.
1861	Apr. 24	43.2	.....	.....	Do.
1862	May 2	50.8	.....	.....	Maj. H. L. Abbot (Chief of Engineers' Reports, 1869, p. 336, and 1875, p. 568), by comparing with 1858.
1865	Mar. 18	48.0	.....	.....	Do.
			Dec. 4	6.5	Cairo City water-gauge records, adding as above.
1866	May 1	42.3	Aug. 18	9.8	Do.
1867	Mar. 21	51.0	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 429).
			Dec. 14	2.7	Cairo City water-gauge records, adding as above.
1868	May 19	45.6	.....	.....	Do.
1871	.....	.....	Dec. 24	—1.0	Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1872	Apr. 19	39.2	Dec. 6	1.0	Major Merrill (water-gauge records).
1873	Feb. 26	41.6	Oct. 15	2.6	Do.
1874	Apr. 26	47.4	.....	.....	Do.
			Nov. 13	3.0	Captain Benyaurd (water-gauge records).
1875	Aug. 8	45.1	Jan. 26	5.3	Do.
1876	Apr. 6	46.4	Dec. 31	0.1	Do.
1877	Apr. 15	40.5	Jan. 1	1.0	Do.
1878	Apr. 29	37.0	Oct. 22	5.9	Do.
1879	Jan. 26	36.0	Oct. 10	2.7	Major Benyaurd (water-gauge records).
1880	Mar. 22	44.6	Nov. 29	5.7	Do.

CARROLLTON GAUGE.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1828	Apr. 1	15.2	.....	.....	H. and A., p. 172, by comparing with 1858.
1844	.....	14.5	.....	.....	Do.
1849	Mar. 12	15.2	Oct. 6	2.1	H. and A., p. 516.
1850	Jan. 21	13.8	Nov. 18	−0.5	H. and A., p. 517.
1851	Mar. 27	15.4	Nov. 24	0.2	H. and A., p. 521.
1852	May 30	14.1	Feb. 4	0.6	H. and A., p. 525.
1853	May 30	15.0	Oct. 26	1.2	H. and A., p. 527.
1854	Apr. 14	14.7	Dec. 30	0.0	H. and A., p. 528.
1858	May 10	15.1	Nov. 5	0.4	H. and A., p. 536.
1859	May 4	15.6	Nov. 13	-0.4	H. and A., p. 540.
1860	Feb. 6	13.4	Oct. 18	−0.7	H. and A., p. 541.
1862	.....	15.9	.....	.....	Major Abbot (Chief of Engineers' Reports, 1869, p. 337, and 1875, p. 568), by comparing with 1858.
1871	.....	15.4	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 434).
1872	May 6	12.3	Dec. 27	−1.6	Major Merrill (water-gauge records).
1873	June 27	13.0	Nov. 20	0.1	Do.
1874	Apr. 16	15.7	.....	.....	Do.
			Nov. 24	0.1	Captain Benyaurd (water-gauge records).
1875	May 3	11.3	Nov. 13	0.1	Do.
1876	May 11	12.7	Dec. 30	−1.2	Do.
1877	June 1	11.0	Jan. 9	−1.4	Do.
1878	Mar. 21	11.3	Nov. 22	−0.1	Do.
1879	Feb. 20	10.8	Nov. 24	−0.8	Major Benyaurd (water-gauge records).
1880	Apr. 23	14.3	Nov. 2	0.3	Do.

FLORENCE GAUGE.

1867	.....	31.1	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 430).
1871	.....	.....	.....	0.0	Do.
1872	Dec. 25	16.4	Oct. 24	−0.8	Major Merrill (water-gauge records).
1873	Feb. 22	22.9	Oct. 21	−0.5	Do.
1874	Apr. 17	26.0	.....	.....	Do.
			Nov. 10	0.0	Captain Benyaurd (water-gauge records).
1875	Mar. 8	29.4	Nov. 3	0.4	Do.
1876	Jan. 4	19.8	Oct. 21	−0.6	Do.
1877	Apr. 10	19.4	Aug. 28	0.0	Do.
1878	Apr. 26	13.6	Sept. 18	−0.8	Do.
1879	Jan. 20	21.5	Oct. 6	−0.5	Major Benyaurd (water-gauge records).
1880	Mar. 18	24.5	Oct. 22	0.0	Do.

FORT LEAVENWORTH GAUGE.

1867	.....	22.1	.....	.....	Major Merrill (Chief of Engineers' Report, 1873, p. 517).
1869	.....	.....	Dec. 25	2.8	Major Merrill (water-gauge records).
1870					
1871	Apr. 13	16.8	Dec. 23	0.8	Do.
1872	June 11	14.0	Nov. 30	0.0	Do.
1873	July 14	16.4	Dec. 3	1.3	Do.
1874	July 6	19.1	Dec. 10	1.8	Do.
1875	June 17	15.9	Jan. 6	1.6	Do.
	Apr. 30	17.7	Jan. 1	2.0	Captain Benyaurd (water-gauge records).
1876					
1877	July 6	16.7	Dec. 6	2.0	Do.
1878	June 13	19.2	Dec. 17	3.8	Do.
1879	July 1	19.0	Dec. 18	3.6	Do.
1880	June 30	16.8	Dec. 18	2.7	Major Benyaurd (water-gauge records).
	July 11	16.5	Feb. 2	1.4	Do.

HELENA GAUGE.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1828		43.1			H. and A., p. 171, by comparing with 1858.
1844		42.2			Do.
1849		42.8			Do.
1850	May 1	42.8			Do.
1851		39.8			Do.
1858	July 2	44.6			Major Abbot (Chief of Engineers' Reports, 1869, p. 336, and 1875, p. 568), by comparing with 1862.
1859	Mar. 22	43.6			H. and A., p. 171, by comparing with 1858.
1862		46.4			Major Merrill (Chief of Engineers' Report 1872, p. 432), by adding 2.2, as per Captain Benyaurd (Chief of Engineers' Report, 1876, p. 606).
1865		44.4			Major Abbot, reference as for 1858.
1867		45.8			Major Merrill, reference as for 1862.
1871			Dec. 29	1.1	Major Merril (water-gauge records), by adding 2.2, as above.
1872	Apr. 26	39.0	Dec. 26	0.0	Do.
1873	Mar. 6	40.0	Oct. 17	4.0	Do.
1874	May 11	45.8			Do.
			Nov. 16	3.7	Captain Benyaurd (water-gauge records).
1875	Apr. 12	42.4	Jan. 28	6.5	Do.
1876	Apr. 18	44.9	Dec. 31	3.0	Do.
1877	Apr. 30	41.8	Jan. 4	1.7	Do.
1878	May 3	38.8	Oct. 25	7.2	Do.
1879	Jan. 31	37.3			Major Benyaurd (water-gauge records).
1880	Mar. 31	43.7	Nov. 3	8.1	Do.

JACKSONPORT GAUGE.

1867		32.8			Major Merrill (Chief of Engineers' Report, 1872, p. 431).
1872	May 24	22.0	Dec. 24	−1.1	Major Merrill (water-gauge records).
1873	Apr. 13	30.0	Sept. 2	−0.7	Do.
1874	Apr. 23	31.1			Do.
			Nov. 3	−0.5	Captain Benyaurd (water-gauge records).
1875	May 6	26.8	Oct. 29	0.0	Do.
1876	Jan. 31	31.7	Dec. 28	0.5	Do.
1877	June 13	26.4	Oct. 7	0.2	Do.
1878			Nov. 14	0.3	Do.
1879	Feb. 8	12.3	Nov. 3	−0.6	Major Benyaurd (water-gauge records).
1880	Mar. 12	27.1	Sept. 13	0.2	Do.

LAKE PROVIDENCE GAUGE.

1862		40.9			Major Merrill (Chief of Engineers' Report, 1872, p. 432).
1867		40.0			Do.
1871			Dec. 31	−2.6	Major Merrill (water-gauge records).
1872	May 1	35.2	Dec. 29	−3.9	Do.
1873	May 28	36.1	Nov. 4	0.9	Do.
1874	Mar. 21	37.4			Do.
			Nov. 16	0.9	Captain Benyaurd (water-gauge records).
1875	Apr. 19	37.3	Nov. 12	5.9	Do.
1876	Apr. 12	38.0	Dec. 31	1.2	Do.
1877	May 6	35.8	Jan. 1	1.2	Do.
1878	Mar. 22	35.8	Oct. 27	3.7	Do.

LAKE PROVIDENCE GAUGE—Continued.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1879	Feb. 14	36.0	Oct. 16	0.5	Major Penyaurd (water-gauge records).
1880	Apr. 3	38 1	Oct. 26	6.0	Do.

LITTLE ROCK GAUGE.

1857	.....	31.0	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 432).
1864	.....	.....	.....	0.0	Do.
1872	May 20	26.0	Dec. 4	0.8	Major Merrill (water-gauge records).
1873	Apr. 12	22.6	Sept. 23	0.4	Do.
1874	Apr. 25	23.0	.....	.....	Do.
			Sept. 4	0.0	Captain Benyaurd (water-gauge records).
1875	Aug. 5	21.8	Nov. 27	0.5	Do.
1876	July 7	26.3	Oct. 18	1.0	Do.
1877	June 13	27.5	Jan. 9	1.3	Do.
1878	May 28	24.3	.....	.....	Do.
1879	Feb. 3	16.6	Oct. 23	—1.0	Major Benyaurd (water-gauge records).
1880	Mar. 15	14.8	May 29	0.8	Do.

LOUISVILLE (UPPER) GAUGE.

1832	.....	40.8	.....	.....	Major Merrill (Chief of Engineers' Report, 1873, p. 518).
1851	Mar. 2	20.3	Oct. 5	1.5	Louisville and Portland Canal water-gauge records, deducting 35 feet, as per Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1856	.....	.....	.....	1.1	Major Merrill (Chief of Engineers' Report, 1873, p. 518).
1858	June 17	19.1	Sept. 28	1.5	Louisville and Portland Canal records, as above.
1859	Feb. 24	33.8	Sept. 20	2.0	Do.
1866	Jan. 1	18.6	Aug. 18	2.8	Do.
1867	Mar. 15	37.6	Oct. 22	1.8	Do.
1868	Mar. 31	22.3	July 30	3.0	Do.
1869	Apr. 4	24.3	Aug. 25	2.8	Do.
1872	Apr. 14	21.0	Oct. 17	2.0	Major Merrill (water-gauge records).
1873	Dec. 19	18.3	Sept. 27	2.3	Do.
1874	Feb. 26	22.4	.....	.....	Do.
			Sept. 22	1.7	Captain Benyaurd (water-gauge records).
1875	Aug. 7	30.3	Sept. 20	2.7	Do.
1876	Jan. 30	32.5	Dec. 18	3.7	Do.
1877	Jan. 21	29.9	Oct. 11	2.2	Do.
1878	Dec. 17	15.5	Oct. 27	2.9	Do.
1879	Dec. 28	19.6	Oct. 18	2.2	Major Benyaurd (water-gauge records).
1880	Feb. 19	30.0	Oct. 2	2.8	Do.

LOUISVILLE (LOWER) GAUGE.

1832	.....	67.5	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 430).
1856	.....	.....	.....	1.0	Do.
1858	June 17	42.3	Oct. 3	1.5	Louisville and Portland Canal water-gauge records, deducting 8 feet, as per Major Merrill (Chief of Engineers' Report 1872, p. 430).
1859	.....	.....	.....	.....	
1866	Feb. 24	57.5	Sept. 20	2.5	Do.
1867	Sept. 27	41.8	Aug. 18	4.7	Do.
	Mar. 15	62.2	Oct. 22	3.0	Do.

LOUISVILLE (LOWER) GAUGE—Continued.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1868	Jan. 11	48.8	Oct. 29	5.1	Louisville and Portland Canal water-gauge records, deducting 8 feet, as per Major Merrill (Chief of Engineers' Report, 1872, p. 430).
1869	Apr. 4	49.0	Nov. 17	4.1	Do.
1872	Apr. 14	45.4	Oct. 17	1.6	Major Merrill (water-gauge records).
1873	Dec. 19	42.8	Oct. 1	3.0	Do.
1874	Feb. 26	47.6	.....	.....	Do.
			Nov. 15	2.8	Captain Benyaurd (water-gauge records).
1875	Aug. 8	55.0	Sept. 20	4.1	Do.
1876	Jan. 30	58.0	Dec. 18	5.3	Do.
1877	Jan. 20	55.2	Oct. 11	3.1	Do.
1878	Dec. 17	42.5	Oct. 27	3.7	Do.
1879	Dec. 28	44.6	Oct. 18	2.8	Major Benyaurd (water-gauge records).
1880	Feb. 19	55.5	Oct. 4	3.6	Do.

MEMPHIS GAUGE.

1828	.....	32.7	.....	.....	H. and A., p. 171, by comparing with 1858.
1844	July —	33.0	.....	.....	Do.
1848	.....	.....	Oct. 29	1.2	H. and A., p. 515, by deducting 1.3, as found by comparing reading for high-water of 1858, p. 532.
1849	Feb. 8	30.7	Sept. 23	3.3	H. and A., p. 516, by deducting as above.
1850	May 14	33.4	Nov. 3	2.3	H. and A., p. 517, by deducting as above.
1851	Mar. 11	33.0	Dec. 27	3.3	H. and A., p. 518, by deducting as above.
1852	Apr. 21	32.8	.....	.....	H. and A., p. 522, by deducting as above.
1858	.....	.....	Oct. 24	2.7	H. and A., p. 532, by deducting as above.
	June 23	34.0	.....	.....	Major Abbot (Chief of Engineers' Report, 1869, p. 336, and 1875, p. 568), by comparing with 1867).
1859	May 12	33.9	.....	.....	Do.
1862	.....	34.45	.....	.....	Do.
1865	.....	33.4	.....	.....	Do.
1867	Mar. 26	33.95	.....	.....	*High-water mark on west wall of gas-works.
1871	.....	.....	Dec. 29	—0.92	Major Merrill (water-gauge records).
1872	Apr. 24	31.5	Dec. 25	—0.95	Do.
1873	Mar. 3	32.5	Oct. 30	1.0	Do.
1874	May 2	34.0	.....	.....	Do.
			Nov. 16	1.4	Captain Benyaurd (water-gauge records).
1875	Aug. 15	33.1	Jan. 27	3.2	Do.
1876	Apr. 8	34.1	Dec. 30	1.2	Do.
1877	Apr. 29	32.1	Jan. 2	0.7	Do.
1878	May 2	29.1	Oct. 24	2.9	Do.
1879	Jan. 29	28.1	Oct. 9	1.0	Major Benyaurd (water-gauge records).
1880	Mar. 24	33.4	Oct. 31	2.6	Do.

* This mark was made at the time of high-water by Mr. Rounds, who was then, and is now, superintendent of the works. It was placed 5 feet above the highest water at that place. It reads on the United States engineer's gauge 39.81 feet. Deducting 5 feet (the height of mark above high-water), gives 34.81 feet for the reading of high-water of 1867 at the gas-works on the United States engineer's gauge. The slope of the river from the gas-works to United States engineer's gauge (a distance of about 1 mile) has been carefully determined at a stage of 33.0 feet on the gauge, and is found to be 0.86 feet. Deducting this from 34.81, we have for the actual reading of high-water of 1867 on the gauge 33.95 feet. This reading was obtained by another method. On April 27, 1881, when the gauge reading was 33.3 feet, the high-water mark of 1867 was 0.65 feet above the water surface at the gas-works; hence the reading of high-water of 1867 on the gauge must have been 33.3 feet + 0.65 feet, or 33.95 feet, as above.

MOUTH OF WHITE RIVER GAUGE.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
		Feet.		*Feet.*	
1862	Apr. 20	48.2	.....	.....	Major Abbot (Chief of Engineers' Report, 1869, p. 336), comparing 1867.*
1867	Mar. 30	46.8	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 432). by adding 3.2 feet, as per Captain Benyaurd (Chief of Engineers' Report, 1876, p. 610).
1871	.....	.....	Dec. —	1.4	Do.
1872	Apr. 30	40.2	Dec. 28	0.0	Major Merrill (water-gauge records, by adding as above).
1873	Apr. 25	42.9	Oct. 22	2.6	Do.
1874	Apr. 28	46.6	.....	.....	Do.
			Nov. 16	2.7	Captain Benyaurd (water-gauge records).
1875	Apr. 16	45.0	Jan. 28	6.8	Do.
1876	Apr. 8	46.7	Dec. 26	2.9	Do.
1877	May 5	44.6	Jan. 8	2.2	Do.
1879	.....	.....	Oct. 14	2.4	Major Benyaurd (water-gauge records).
1880	Mar. 23	46.6	Nov. 4	7.0	Do.

*Major Abbot gives the comparison for a gauge about 1 mile above the mouth, and one about 3 miles below. Neither of these would be correct for the present gauge, as it is about one-half mile below the mouth. An interpolated difference of 1.4 feet has been used.

NASHVILLE GAUGE.

1847	.....	54.7	.....	.....	Major Merrill (Chief of Engineers' Report, 1874, p. 489).
1873	.....	.....	Oct. 14	0.5	Major Merrill (water-gauge records).
1874	Apr. 17	49.6	July 10	0.5	Do.
1875	Mar. 2	41.5	Sept. 18	1.2	Captain Benyaurd (water-gauge records).
1876	Jan. 29	34.4	Oct. 20	0.3	Do.
1877	Jan. 22	40.5	Oct. 21	0.8	Do.
1878	Apr. 26	27.3	Oct. 15	—0.4	Do.
1879	Jan. 19	41.6	Oct. 6	—0.2	Major Benyaurd (water-gauge records).
1880	Mar. 20	46.5	Oct. 15	0.5	Do.

NATCHEZ GAUGE.*

1828	Mar. 26	48.9	.....	.....	H. and A., p. 172, by comparing with 1858.
1844	July 16	48.3	.....	.....	Do.
1849	.....	47.9	.....	.....	Do.
1850	.....	47.7	.....	.....	Do.
1851	Apr. 3	47.5	.....	.....	Do.
1858	June 28	48.2	.....	.....	Major Abbot (Chief of Engineers' Report, 1875, p. 568), comparing with 1867.
1859	May 2	49.4	.....	.....	H. and A., p. 172, by comparing with 1858.
1862	.....	50.3	.....	.....	Major Abbot (Chief of Engineers' Report, 1875, p. 568), comparing with 1867.
1867	.....	47.9	.....	.....	Major Merrill (Chief of Engineers' Report, 1873, p. 521), adding 1.2, as per Captain Benyaurd (Chief of Engineer's Report, 1876, p. 612).
1868	.....	43.9	.....	.....	Do.
1869	.....	46.1	.....	.....	Do.
1870	.....	44.3	.....	.....	Do.
1871	.....	43.8	.....	.....	Captain Benyaurd (Chief of Engineers' Report, 1876, p. 613).
				1.2	Major Merrill (Chief of Engineers' Report, 1872, p. 433), adding 1.2, as above.

*Records at this station for other years besides those in the table are given by diagrams on Plate of Humphrey and Abbot's Report on Mississippi River.

NATCHEZ GAUGE—Continued.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
1872	May 2	39.9	Dec. 15	0.0	Major Merrill (water-gauge records, 1872).
1873	May 30	40.2	Jan. 1	0.9	Do.
1874	Apr. 20	45.6	.....	.....	Do.
			Nov. 17	2.7	Captain Benyaurd (water-gauge records).
1875	Apr. 25	41.9	Jan. 1	7.0	Do.
1876	May 15	43.9	Dec. 31	2.9	Do.
1877	May 30	40.7	Jan. 9	1.4	Do.
1878	Mar. 28	39.2	Nov. 8	6.3	Do.
1879	Feb. 17	36.8	Oct. 18	1.8	Major Benyaurd (water-gauge records).
1880	Apr. 16	43.5	Oct. 28	7.3	Do.

RED RIVER LANDING GAUGE.

1867	.....	46.3	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 434), adding 3.0, as per Captain Benyaurd (Chief of Engineers' Report, 1876, p. 614).
1871	.....	44.5			Do.
			Dec. 31	2.0	Major Merrill (water-gauge records), adding 3.0, as above.
1872	May 6	39.4	Dec. 15	0.0	Do.
1873	June 12	39.0	Jan. 1	1.5	Do.
1874	Apr. 16	47.0	.....	.....	Do.
			Nov. 22	1.9	Captain Benyaurd (water-gauge records).
1875	May 3	40.5	Jan. 1	6.0	Do.
1876	May 15	45.4	Dec. 30	2.2	Do.
1877	June 1	40.6	Jan. 8	0.8	Do.
1879	Feb. 19	35.9	Oct. 24	0.5	Major Benyaurd (water-gauge records).
1880	Apr. 22	44.1	Oct. 26	6.1	Do.

SAINT LOUIS GAUGE.

1826	.....	33.8	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1828	.....	36.4	.....	.....	H. and A., p. 171, by comparing with 1844.
1844	June 28	41.4	.....	.....	Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1851	June 10	36.7	.....	.....	H. and A., p. 171, by comparing with 1844.
1855	.....	37.1	.....	.....	Major Merrill, Chief of Engineers' Report, 1872, p. 429).
1858	June 15	37.1	.....	.....	H. and A., p. 171, by comparing with 1844.
1860	.....	.....	Dec. 27	0.6	City of Saint Louis gauge records, by adding 33.8, as per Major Merrill (Chief of Engineers' Report, 1872, p. 429).
1861	May 15	25.5	Jan. 1	1.3	Do.
1862	Apr. 26	31.5	Jan. 8	3.5	Do.
1863	Mar. 4	18.0	Dec. 21	0.0	Do.
1864	May 14	20.3	Jan. 2	1.2	Do.
1865	July 28	26.8	Feb. 2	1.2	Do.
1866	Apr. 25	26.8	Dec. 21	5.8	Do.
1867	May 1	28.2	Dec. 19	1.3	Do.
1868	May 14	24.2	Jan. 14	0.8	Do.
1869	July 24	29.3	Jan. 2	5.6	Do.
1870	Apr. 16	26.2	Dec. 24	5.3	Do.
1871	.....	.....	Dec. 21	2.8	Major Merrill (water-gauge records).
1872	June 12	23.0	Dec. 4	2.5	Do.
1873	Apr. 11	25.5	Nov. 30	3.9	Do.
1874	June 19	18.4	.....	.....	Do.

SAINT LOUIS GAUGE—Continued.

Year.	High-water.		Low-water.		Authorities.
	Date.	Gauge reading.	Date.	Gauge reading.	
		Feet.		*Feet.*	
			Dec. 31	2.8	Captain Benyaurd (water-gauge records).
1875	Aug. 3	29.8	Jan. 3	2.3	Do.
1876	May 10	32.1	Feb. 7	5.0	Do.
1877	June 14	26.6	Oct. 4	6.8	Do.
1878	June 15	25.8	Dec. 25	5.6	Do.
1879	July 3	21.2	Dec. 26	3.5	Major Benyaurd (water-gauge records).
1880	July 12	25.5	Nov. 29	2.8	Do.

VICKSBURG GAUGE.

1828	.....	48.3	.....	.....	H. and A., p. 172, by comparing with 1858.
1844	June 28	48.1	.....	.....	Do.
1849	Apr. 26	48.3	.....	.....	Do.
1850	June 4	49.0	.....	.....	Do.
1858	June 26	48.9	.....	.....	Major Abbot (Chief of Engineers' Report, 1869, p. 337), by comparing with 1862.
			Oct. 31	9.2	H. and A., p. 534, by adding 0.6, as found by comparing high-water of this year.
1859	Apr. 21	50.2	.....	.....	Major Abbot (Chief of Engineers' Report, 1869, p. 337), compared with 1862.
1862	Apr. 27	51.1	.....	.....	Major Merrill (Chief of Engineer's Report, 1872, p. 433).
1865	.....	48.4	.....	.....	Major Abbot (Chief of Engineers' Report, 1869, p. 337), compared with 1862.
1867	.....	48.8	.....	.....	Do.
1871	.....	.....	Dec. 31	—0.4	Major Merrill (water-gauge records).
1872	May 2	39.5	Dec. 30	—1.3	Do.
1873	May 29	40.6	Jan. 1	2.3	Do.
1874	May 2	45.7	.....	.....	Do.
			Nov. 16	3.1	Captain Benyaurd (water-gauge records).
1875	Apr. 21	43.0	Nov. 13	8.1	Do.
1876	May 10	44.9	Dec 30	4.0	Do.
1877	May 8	41.6	Jan. 6	2.2	Do.
1878	Mar. 24	41.0	.....	.....	Do.
1879	Feb. 17	39.5	.....	.....	Major Benyaurd (water-gauge records).
1880	Apr. 8	43 2	Oct. 27	7.7	Do.

EXTREME HIGH AND LOW WATER.

For convenient reference, the following table of the highest and lowest recorded readings on the gauges at the several stations is compiled from the preceding tables. It also contains the extreme oscillations as determined by taking the difference between highest and lowest readings at each station.

Tables of extreme high and low water.

Stations.	Highest water on record.		Lowest water on record.		Extreme oscillation.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
		Feet.		*Feet.*	
Louisville (Upper)	—— —, 1832	40.8	—— —, 1856	1.1	39.7
Louisville (Lower)	—— —, 1832	67.5	—— —, 1856	1.0	66.5
Florence	—— —, 1867	31.1	Oct. 24, 1872 / Sept. 18, 1878	*−0.8	31.9
Nashville	—— —, 1847	54.7	Oct. 15, 1878	−0.4	55.1
Fort Leavenworth	—— —, 1867	22.1	Nov. 30, 1871	0.0	22.1
Saint Louis	June 28, 1844	44.1	Dec. 21, 1863	0.0	41.4
Cairo	Mar. 21, 1867	51.0	Dec. 25, 1871	−1.0	52.0
Memphis	—— —, 1862	34.5	Dec. 25, 1872	−1.0	35.5
Helena	—— —, 1862	46.4	Dec. 26, 1872	0.0	46.4
Jacksonport	—— —, 1867	32.8	Dec. 24, 1872	−1.1	33.9
Little Rock	—— —, 1857	31.0	Oct. 23, 1879	−1.0	32.0
Mouth White River	Apr. 20, 1862	48.2	Dec. 28, 1872	0.0	48.2
Lake Providence	—— —, 1862	50.9	Dec. 29, 1872	−3.9	44.8
Vicksburg	Apr. 27, 1862	51.1	Dec. 30, 1872	−1.3	52.4
Natchez	—— —, 1862	40.9	Dec. 15, 1872	0.0	50.3
Alexandria	—— —, 1866	36.5	Nov. 1, 1879	−3.1	39.6
Red River Landing	Apr. 16, 1874	47.0	Dec. 15, 1872	0.0	47.0
Baton Rouge	Apr. 16, 1874	36.2	—— —, 1854	0.2	36.0
Carrollton	—— —, 1862	15.9	Dec. 27, 1872	−1.6	17.5

* The sign — denotes below the zero of the gauge.

The above table shows the flood of 1862 to have produced the highest water known at all stations on the main river below Cairo, except at Red River Landing and Baton Rouge. At the former we have no record for 1862, and at the latter the flood of 1862 was exceeded by that of 1874 by only one-tenth of a foot. (See gauge table for this station.)

The perfection attained in the levee system in Louisiana just previous to the great crevasses at Bonnet Carré, Morganzia, Hickey, and other places below Red River Landing, about April 16, 1874, may account for the higher stage at Baton Rouge in this year than in 1862, when a stage 0.5 foot higher was reached at Memphis, and 5.4 feet higher at Vicksburg, than in 1874. (See gauge tables.) Had the levees on the Atchafalaya and on the main river below mouth of Red been of sufficient height and strength to have confined the flood crest which passed Vicksburg on May 2, 1874, a still higher mark would have been reached at Baton Rouge and other lower stations.

The lowest water of which we have a record at all stations below Cairo on the main river, except Baton Rouge, was that of 1872. The exception mentioned appears somewhat anomalous, inasmuch as the lowest reading at Carrollton for 1872 was 1.6 feet lower than that for 1854, while at Baton Rouge the record makes it 0.9 foot higher.

RESULTS FROM RECORDS FOR THE NINE YEARS BEGINNING 1872 AND ENDING 1880.

The table and charts* which follow have been elaborated from the water-gauge records obtained during the nine years from 1872 to 1880, inclusive, under the present system of water-gauges.

During this interval the only important omissions in the record occur in the year 1878; and these are due to the fact that no appropriation for maintenance of water-gauges was made for the fiscal year ending June, 1878, and to the prevalence of yellow fever in the Lower Mississippi Valley during the summer of that year. Some of the observers continued the observations, however, without pay, and for some stations the record is complete.

In compiling the table and constructing the charts the object has been to present in a concise form all the data furnished by the records which have a practical bearing

* An explanation of the charts is given at the end of this report.

upon the navigation of the Lower Mississippi, the overflow of the banks, and the question of its improvement, whether in the interest of commerce or the planter on its adjacent bottom lands. With this object in view it seemed unnecessary to consider the medium water-stages.

Unquestionably a longer period than the nine years here included would furnish a more reliable basis upon which to predicate the inferences to be drawn therefrom, but this interval is of sufficient duration to afford many indications of what may be expected, in the near future at least, in respect of the probable limits of high and low water, the time of year in which each may be looked for, and from a knowledge of the conditions existing at upper stations at any time during high or low water, the stage that will be reached at any lower station may be foretold with a degree of accuracy sufficient to be of practical value.

HIGHEST WATER.

In columns 2 and 3 of the table, the date and gauge-reading of the highest water, for the period under consideration, is given for each station.

This shows the high-water year at all stations on the main river, except Memphis, mouth of White River, and Lake Providence, to have been 1874. At the first two of these exceptional stations the flood of 1876 exceeded that of 1874 by only one-tenth of a foot, and at all stations below Cairo the two years ran near the same mark.

That 1880 gave a higher reading at Lake Providence than 1874 is probably because the large breaks at Ashton, Upper and Lower Bass (near this station), in 1874 greatly reduced the flood stage that year.

It will be observed that at nearly all stations on the main river the highest water has occurred in April.

LOWEST WATER.

Columns 4 and 5 of the table, giving the date and reading of lowest water, show that 1872 was the low-water year on the main river, with Baton Rouge exceptional, where in 1877 0.2 feet lower was reached than in 1872.

December is shown to be decidedly the month of lowest water.

VERTICAL OSCILLATION.

In the next five columns of the table will be found the extreme oscillation for the entire period, and the maximum and minimum oscillation for any one year for each station with the year in which such maximum or minimum occurred.

The year of maximum range corresponds closely with that of highest water, being for stations on the lower river, with few exceptions, the year 1874, while for a minimum range the years 1878–'79 predominate.

It will be remarked also that the difference between the maximum and minimum range for a single year is much greater than the difference between this maximum and the extreme range at all stations.

HIGH AND LOW WATER LIMITS.

In order to arrive at a comparison of certain high and low water conditions, as developed on the accompanying charts, a high-water limit and a low-water limit have been assumed for each station.

All records at and above a certain reading on each gauge are taken as high-water records, and all those at and below a certain other reading on each gauge are taken as low-water records.

These readings are designated as the high and low water limits respectively, varying at the different stations and greatly dependent upon the range of oscillation at the locality.

In deciding upon the most suitable value for these limits many points for consideration arose, amongst which are the following more important ones, viz:

1. High-water should include all stages which might be dangerous either from overflow or threatening levees and other improvements.
2. Low-water should include all stages which would interfere with navigation on account of shoal-water.
3. It seemed desirable that any high or low water showing as such at any station on the main river should so show at all stations on it, and that their duration should be about equal at all consecutive stations.
4. That it would be well to have at least one high-water and one low-water period at each station in each year.
5. That the range of both high and low water readings should be as short as possible, yet cover substantially the foregoing requirements.

Whether or not all these conditions are fulfilled, in a general sense only, depends, of course, upon the values assumed for the limits.

With these and minor considerations in view, and after much labor in tabulating and making comparisons from the records, the limits as given in the two columns of the table headed high-water and low-water, respectively were adopted. While it is not presumed that they are the best which might have been selected, it is thought they will subserve the objects contemplated.

HIGH-WATER.

As before stated, all stages at and above the high-water limit as assumed at any station are regarded as high-water at that station.

In the chart will be found the number of days' duration of each high-water period, and the total number of high-water days for each year is given in the table. On account of incomplete records, several blanks occur on the charts and in the table.

In several instances the high-water limit was not reached during an entire year. In such cases the date of maximum stage is noted by a dot and the reading inclosed by a parenthesis, as for Saint Louis on the chart for 1874.

The table shows that the greatest number of high-water days at all stations on the Mississippi in any one year occurred in 1876, and the fewest number in 1879 and 1872.

In the column of the table headed "Yearly average of high-water," the average number of high-water days is given for each station. Where, on account of incomplete records, the number of high-water days in any year is unknown, an interpolated number for that year was used in determining the average. Evidently the case does not admit of accurate interpolation, though the error in the average obtained must of necessity be small.

It will be observed that the yearly average of high-water days increases, in a general sense, from the upper to the lower stations, while the high-water range diminishes.

As to the time of year in which high-water may be expected, the charts show that the earliest beginning of high-water on the lower river was early in January, 1880, and the latest ending during the first days of September, 1875. Hence, high-water is possible at any time during a period of eight months, beginning with January. The longest high-water season was that of 1876, from the middle of January to the latter part of July; in all, a period of about six and a half months. The shortest season was that of 1879, beginning and ending in February. As an average result, February, March, April, May, and June may be regarded as the high-water months.

LOW-WATER.

All stages at and below the low-water limit as given in the table, at any station, are regarded as low-water at that station. The number of days' duration of each low-water period is given on the charts, and the total number of low-water days for each year is given in the table.

As in the case of high-water, some blanks occur on charts and tables, also in several instances the limit has not been reached during an entire year.

Reference to the table shows that for all stations on the Mississippi River the number of low-water days in 1872 was greatly in excess of that of any other year, and that the fewest number occurred in 1875 and 1880.

Generally speaking, the "yearly average of low-water days" (given in a proper column in the table) decreases as we pass from upper to lower stations, although the low-water range increases, except at Baton Rouge and Carrollton, where the range is very small. These averages were obtained in the manner described for high-water averages.

It will be observed that from the charts we find the earliest beginning of low-water on the lower river in the latter part of August, 1874, and the latest ending in latter part of January, 1877. So that low-water may be looked for at any time during a period of five months, beginning with the last days of August.

The longest low-water season was that of 1872, from middle of September to early January; in all, a period of about three and a half months. The shortest season was that of 1875, in November, when the limit was not reached at many stations.

September, October, November, and December may be considered as the low-water months.

THE EFFECT OF TRIBUTARIES ON THE HIGH-WATER STAGE OF THE MAIN RIVER.

The attempt to discover the effect, in a general way, that the principal tributaries have had in raising or lowering a high-water stage on the main river first suggested the construction of hydrographs for all stations for the same year on the same sheet, having the stations arranged in order from Louisville (most remote from the Gulf) downward, and placing those on other tributaries in such order that they fall between the same two stations on the main river as does the entrance of such tributary. In this arrangement the effect resulting from the stage in each tributary upon that in the main stream may be discernible.

A knowledge of the relative effects of the eastern and western watersheds in producing high-water in the main stream may be obtained from the charts by a study of

the high-water hydrographs as there presented. A brief reference to each chart is here appended in an illustrative way.

1872.—This chart shows the highest water below to have come from the Ohio, with no material additions from other tributaries, though a few days later the limit was again reached at Red River Landing and below, through the combined effect of the White, Arkansas, and Red, with but few high-water days, however, and but slightly above the limit. The Missouri and Upper Mississippi rise as shown opposite station Saint Louis came later and fell far short of the limits below.

1873.—The first and highest water for this year at Cairo, Memphis, and Helena came out of the Ohio, Cumberland, and (presumably) Tennessee, while at all the lower stations a slightly higher mark was reached about two months later, by the combined rise of all the tributaries except the Red. A rise in the latter still later prolonged the high-water period below. A later rise at Leavenworth and Saint Louis produced no material effect below.

1874.—The flood of this year was from the Ohio, Cumberland, and Tennessee, with an increment below from the White and Arkansas, and from the Red for lower stations. The only high-water in the Missouri came much later, while at Saint Louis the limit was not reached during the year.

1875.—Again the highest stage was independent of the Missouri and Upper Mississippi, though the White and Arkansas supplied a high stage. The last high-water was the joint effect of east and west watersheds.

1876.—On this chart are four high-water periods at Cairo, Helena, mouth of White, and Lake Providence, three at Memphis, two at Vicksburg, Natchez, and Red River Landing, all united into one long period of 181 days at Baton Rouge.

The third of these periods was slightly influenced by the stage at Saint Louis, and the last appears to have been mainly from the same source, with some increase from White and Arkansas.

The hydrographs on this chart indicate a great rainfall in the near vicinity of the main river during March and April, as the tributaries do not show a rise sufficient to create the flood stages registered below.

Here is seen the insignificance of the waters of the Red River in producing an effect on the stage of the Mississippi when the latter is near extreme flood. The hydrograph for Red River Landing appears as though absolutely independent of that for Alexandria.

1877.—The first period in this year was by a sudden great rise in the Ohio, no other tributary conspiring. The later period results from the joint effect of all tributaries.

1878.—Exceptional to the general case, we have here the first period following high-water at Saint Louis, with no high stage in the Ohio. A second period was much the same. It should be remarked, however, that the limit was barely passed at all stations, and that we find no high-water following the highest stage at Saint Louis.

1879.—High-water appears entirely independent this year of a high stage at Saint Louis.

1880.—Again the Missouri and Upper Mississippi have had no effect upon the high-water records below, although a high stage was reached on the main river.

It will be observed, then, that in no instance during this period of nine years has the highest stage in any year on the lower river followed the highest stage at Saint Louis; that only in the years 1873–'77–'78 a high-water below immediately follows one at Saint Louis, and that, as a rule, the maximum stage on the main river has transpired during a low stage at Saint Louis. Consequently, no danger from flood-waters should be expected below, from a flood in the Missouri and Upper Mississippi, without a synchronous high-water in one or all of the main drainage-channels of the western slope of the Appalachian range.

PROGRESS OF THE HIGH-WATER APEX.

An important feature of the charts is the facility they offer for a study of the rate of motion of the crest or apex of the different high-waters in their progress from station to station; although each has a rate *sui generis* depending upon the stage of tributary streams, the amount and distribution of rainfall in the immediate vicinity of the river, and the height of the apex, a high-flood apex always moving more slowly than a low one, other circumstances being the same. Examination of the charts show this to be the rule.

On account of the many circumstances bearing upon the rate of motion, causing a different rate for each apex, only an approximation to the average time required in passing from one station to the next lower can be claimed for the number of days given in the last column but two of the table. These numbers were obtained by considering only those cases in which the high-water was not materially affected by a high stage of the tributary entering the main channel between the two stations under consideration. The average of the number of days required for each high-water apex so circumstanced to pass from a station to the next gave the figures found in the table.

The time required in passing from each station to Carrollton, given in the last column of the table, is deduced directly from the preceding column.

In several instances, notably during the flood of 1874, the highest stage has been reached at a station earlier than at the station immediately above. On the chart for this year we find the maximum was reached at Red River Landing on April 16, while at Natchez the rise continued until April 20, and at Vicksburg until May 2. Also at Lake Providence, the station next above Vicksburg, the maximum occurred March 21—41 days earlier than at the latter station. This apparent anomaly is fully explained by the record of crevasses in the Chief of Engineers' Report for 1875, page 604. It appears there that the Ashton, Upper Bass, and Lower Bass breaks, all in the immediate vicinity of Lake Providence, and aggregating 18,400 feet wide, were open on March 21 (the time of extreme high-water for 1874), thus giving early relief. Again, further on in the record we find that the great Morganzia break, 1,710 feet wide and 16 feet deep, between Red River Landing and Baton Rouge, opened on April 16; and although the dates are not given in the record for other breaks on this reach of the river, and the extensive Hickey break just below Baton Rouge, it is known they occurred about the same time. These, with others of less importance, gave such prompt relief at Red River Landing, Baton Rouge, and Carrollton that a decline commenced on April 17 at the three stations.

The same record shows large crevasses to have occurred at different points between Vicksburg and Natchez in this year, previous to date of maximum stage at Natchez. This caused a decline at the latter place twelve days earlier than at Vicksburg.

Here is presented a strong (if not an unanswerable) argument against the theory that outlets have an appreciable effect in lowering the flood-waters at any great distance above such outlets. The Diamond Bend break, only 9 miles below Vicksburg, was, according to the record above referred to, 35,000 feet wide and 4 feet deep, and others between this and Grand Gulf, 40 miles below, aggregating about 5,000 feet wide and from 4 to 9 feet deep, were all open at the time of maximum stage at Natchez. Yet, notwithstanding this great dispersion from the main channel so near Vicksburg, and causing a decline at Natchez from April 20, the rise continued at Vicksburg until it culminated in a 45.7-foot stage on May 2, and remained stationary during four days. Throughout this interval the water at Lake Providence was almost stationary at about 37 feet, or 8.7 feet lower than at Vicksburg. In 1876, 38 feet at Lake Providence gave 44.9 feet at Vicksburg, a difference of only 6.9 feet; and in 1867, 40 feet at Lake Providence gave 48.8 at Vicksburg, a difference of 8.8 feet. Hence the excess in the gauge reading at Vicksburg over that at Lake Providence was 0.1 foot less in 1874 than in 1867, and 1.8 feet more than in 1876, in all of which years the maximum stage was nearly the same. Consequently the normal height due to a certain stage at Lake Providence was reached at Vicksburg in 1874, and we are forced to the conclusion that the great outlet but 9 miles below, with the combined effect of others still deeper, and within a distance of 40 miles below, exerted no appreciable influence in lowering the flood stage at Vicksburg.

Table of high and low water during the period from 1872 *to* 1880, *inclusive.*

The sign — placed before a reading signifies below zero on the gauge. Dotted lines denote that records are incomplete.

Station.	Highest water.		Lowest water.		Oscillation.				
	Date.	Gauge reading.	Date.	Gauge reading.	Extreme.	Maximum for any one year.		Minimum for any one year.	
		Feet.		*Feet.*	*Feet.*	*Year.*	*Feet.*	*Year.*	*Feet.*
Louisville (Upper)	Jan. 30, 1876	32.5	Sept. 22, 1874	1.7	30.8	1876	28.8	1878	12.6
Louisville (Lower)	Jan. 30, 1876	58.0	Apr. 14, 1872	1.6	56.4	1876	52.7	1878	38.8
Florence	Mar. 8, 1875	29.4	Oct. 24, 1872 / Sept. 18, 1878	—0.8	30.2	1875	29.0	1878	14.4
Nashville	Apr. 17, 1874	49.6	Oct. 15, 1878	—0.4	50.0	1874	49.1	1878	27.7
Fort Leavenworth	June 13, 1877	19.2	Dec. 3, 1872	1.3	17.9	1873	17.3	1879	14.1
Saint Louis	May 10, 1876	32.1	Jan. 3, 1875	2.3	29.8	1875	27.5	1874	15.6
Cairo	Apr. 26, 1874	47.4	Dec. 31, 1876	0.1	47.3	1876	46.3	1878	31.1
Memphis	Apr. 8, 1876	34.1	Dec. 25, 1872	—1.0	35.1	1876	32.9	1878	26.2
Helena	May 11, 1874	45.8	Dec. 26, 1872	0.0	45.8	1874	42.1	1878	31.6
Jacksonport	Jan. 31, 1876	31.7	Dec. 24, 1872	—1.1	32.8	1874	31.6	1879	12.9
Little Rock	Jun. 13, 1877	27.5	Oct. 23, 1879	—1.0	28.5	1877	26.2	1880	14.0
Mouth of White River	Apr. 8, 1876	46.7	Dec. 28, 1872	0.0	46.7	1874	43.9	.....	.....
Lake Providence	Apr. 3, 1880	38.1	Dec. 29, 1872	—3.9	42.0	1872	39.0	1875	31.4
Vicksburg	May 2, 1874	45.7	Dec. 30, 1872	—1.3	47.0	1874	42.6	.....	.....
Natchez	Apr. 20, 1874	45.6	Dec. 15, 1872	0.0	45.6	1874	42.9	1878	32.9
Alexandria	May 8, 1874	34.9	Nov. 1, 1879	—3.1	38.0	1874	36.9	1879	22.3
Red River Landing	Apr. 16, 1874	47.0	Dec. 15, 1872	0.0	47.0	1874	45.1	1875	34.5
Baton Rouge	Apr. 16, 1874	36.2	Jan. 9, 1877	0.9	35.3	1874	33.9	1879	24.1
Carrollton	Apr. 16, 1874	15.7	Dec. 27, 1872	—1.6	17.3	1874	15.6	1875	11.2

Table of high and low water during the period from 1872 *to* 1880, *inclusive*—Continued.

Station.	Gauge readings at and above high water.	Gauge readings at and above low-water.	1872.		1873.		1874.		1875.		1876.	
			High-water.	Low-water.	High-water.	Low-water.	High-water.	Low-water.	High-water.	Low-water.	High-water.	Low-water.
	Feet.	*Feet.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Louisville (Upper)	16	4	9	109	7	52	26	112	22	28	22	8
Louisville (Lower)	40	6	10	120	7	49	29	112	25	43	25	8
Florence	15	1	5	135	20	96	37	71	50	27	8	125
Nashville	34	2	.....	.....	.....	.....	33	91	21	17	1	91
Fort Leavenworth	15	5	27	62	46	71	9	115	31	110	30	56
Saint Louis	22	7	8	131	65	106	0	91	56	95	102	5
Cairo	35	7	14	124	41	59	77	89	88	20	103	22
Memphis	26	4	18	135	66	59	85	72	96	4	119	17
Helena	35	8	17	135	62	60	88	93	104	14	137	18
Jacksonport	22	1	1	152	20	135	56	128	13	70	61	34
Little Rock	18	2	26	90	10	92	17	110	8	79	34	65
Mouth of White River	38	8	9	..	80	75	.....	88	112	3	168	17
Lake Providence	33	5	17	137	80	61	93	84	117	0	177	15
Vicksburg	37	7	18	134	85	60	98	72	120	0	197	12
Natchez	36	7	23	129	.....	58	102	80	119	1	190	13
Alexandria	23	0	49	83	34	21	96	81	12	57	84	92
Red River Landing	34	6	39	121	105	.....	.....	.....	113	1	196	15
Baton Rouge	26	4	33	121	105	70	113	86	101	1	181	12
Carrollton	10	1	48	138	124	43	130	55	99	31	160	45

Station.	1877.		1878.		1879.		1880.		Yearly average of high-water.	Yearly average of low-water.	Motion of high-water apex.	
	High-water.	Low-water.	High-water.	Low-water.	High-water.	Low-water.	High-water.	Low-water.			To the next lower station.	To Carrollton.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Louisville (Upper)	11	88	00	24	5	98	29	60	14.6	64.3	0.0	36.2
Louisville (Lower)	12	88	2	43	5	106	31	67	16.2	70.7	5.0	36.2
Florence	17	71	0	119	13	112	27	68	19.7	91.6	.....	.....
Nashville	11	79	0	117	16	128	33	78	16.4	85.9	.....	.....
Fort Leavenworth	48	23	56	41	20	99	23	95	32.2	74.7	4.2	39.1
Saint Louis	66	6	47	12	00	15	23	40	41.1	55.7	3.7	34.9
Cairo	38	60	9	32	7	54	76	11	50.3	52.3	4.8	31.2
Memphis	53	37	20	40	12	62	95	36	62.7	51.3	4.2	26.4
Helena	65	50	42	.....	20	.....	112	00	71.9	55.4	3.2	22.2
Jacksonport	.....	.....	.....	.....	00	100	19	83	24.3	100.3	.....	.....
Little Rock	28	33	.....	.....	00	184	00	103	15.4	94.5	.....	.....
Mouth of White River	85	42	.....	.....	.....	61	115	14	83.4	53.6	4.3	19.0
Lake Providence	72	32	69	36	23	59	119	00	85.2	47.1	3.8	14.7
Vicksburg	96	.....	82	.....	23	....	114	00	92.4	45.1	5.8	10.9
Natchez	97	42	76	21	11	58	113	00	91.8	44.7	3.4	5.1
Alexandria	23	88	61	66	00	172	00	34	39.9	77.1	3.0	4.7
Red River Landing	99	74	.....	.....	22	64	98	00	96.9	50.4	1.1	1.7
Baton Rouge	96	40	87	27	5	50	109	5	92.2	45.8	0.6	0.6
Carrollton	88	59	111	37	24	36	130	10	101.6	50.3	.....	0.0

P 29.

EXAMINATION OF BAYOU BARTHOLOMEW, ARKANSAS AND LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1880.

GENERAL: I have the honor to present the following report upon Bayou Bartholomew, Arkansas and Louisiana, with estimate of cost of

improving same, in accordance with act of Congress approved June 14, 1880:

PREVIOUS SURVEYS, EXAMINATIONS, ETC.

The State of Louisiana has, at various times, caused surveys of that portion of the bayou lying within its boundaries to be made, and various sums have been appropriated and expended in the work of removing obstructions from the stream. The State of Arkansas has likewise at times expended money in the same direction for the portion of the bayou lying between the north boundary of Ashley County and the State line.

In 1872 an examination of the bayou from the State line between Arkansas and Louisiana to its mouth was made in accordance with act of Congress, the report upon which will be found in the report of the Chief of Engineers for 1872, Part II, page 383. No appropriation, however, was made for the improvement according to the estimate then presented.

In 1876, having the snag-boat Wagner at work in the Ouachita, I directed that certain obstructions in the lower part of the bayou be removed, in order to assist the shipment of the crops of that section of the adjoining country, whose only outlet was through the bayou. The Wagner worked to Point Pleasant, a distance of 30 miles, and was then withdrawn.

In accordance with the provisions of the river and harbor act of June 18, 1878, I caused another examination of the bayou to be made. The report thereon will be found in the report of the Chief of Engineers for 1879, page 997.

From the reports above noted, and from a recent examination made under my direction by Mr. John J. Barry, I am enabled to present a report containing all the information necessary upon which to base estimates for the improvement of the bayou.

The bayou takes its rise in the State of Arkansas, within a few miles of Pine Bluff, on the Arkansas River, and, following an exceedingly tortuous course, flows at first nearly parallel to the Arkansas River, at distances from it varying from 15 to 30 miles; then parallel to the Mississippi River at about the same average distance, and after entering Louisiana it diverges to the southwest and empties into the Ouachita River opposite Ouachita City. In Arkansas it flows through Jefferson, Lincoln, Drew, and Ashley counties, and in Louisiana through Morehouse Parish.

The bayou is crossed at Baxter Station (Crew County) by the Mississippi and Texas Railroad, which has its starting point on the Mississippi River at Arkansas City. The distance from Bird Springs, the headwaters of the Bartholomew, to Baxter Station is estimated at 120 miles. At this point the channel is about 100 feet wide, with a depth at low-water of about 3 feet. The bridge crossing is a trestle-work 350 feet long, with bents 12½ feet between centers, the height of the rail being about 22 feet above the bed of the stream. As ordinary high-water comes within 4 feet of the rail, it will be seen that the bridge is a bar to all navigation above the crossing except to stave-boats, of which there are a great many upon this section of the stream. I deem it therefore only necessary to consider the navigable portion of the bayou, from Baxter Station to the mouth, and to present estimates for the improvement of the same.

BAXTER STATION TO THE LOUISIANA STATE LINE.

In this stretch, a distance of 110 miles, the bayou is in a very unsafe condition, either in high or low water, on account of the various obstructions which fill the bed and line the banks of the stream.

In the first 25 miles (from Baxter to Rust's) the bayou varies from 50 to 150 feet in width, with a depth varying from 4 to 10 feet at low-water, except upon the shoal places, where at times only 12 inches can be found.

From Rust's to the State line the bayou varies from 90 to 180 feet in width, and, except at the shoals and fords, is from 5 to 10 feet deep at low-water. The current for the greater part of the distance is quite sluggish, seldom attaining a greater rate than 1½ miles per hour.

The Wiggins place, about half way between Baxter and Rust's, is virtually the head of navigation. Since the construction of the railroad above, boats have seldom gone as high as Baxter. Some of the steamers make round trips to and from New Orleans; others connect at Trenton and Monroe with the regular New Orleans and Ouachita River packets.

OBSTRUCTIONS TO NAVIGATION.

The serious obstructions to navigation are the snags, logs, and overhanging trees. A hurricane crossed the bayou several years ago at a point about 1 mile above Portland, and here the trees are lying thick across the stream, though there is quite a good depth of water in the vicinity. Some of these obstructions have been cut in order to allow boats to pass at ordinary good stages of water, but at low-water the place is said to be impassable. In addition there are the following-named fords:

Name.	Depth in feet at low-water.	Name.	Depth in feet at low-water.
Gaster'	1	Bloomer's	
Rust's	2	Sanford's	3
Townsend's	2	Sandy Point	3
Mrs. Womack's	1½	Smith	2½
Perkin's	3½	Dade	3
Shearer's	2½	Eastman	3
Pugh	3		

LOUISIANA LINE TO OUACHITA RIVER.

This stretch is 103 miles in length, according to the measured distance taken from a map of the bayou, surveyed by the board of State engineers of Louisiana. The bayou is exceedingly tortuous, there being many bends where the distance across the neck is about ½ mile, while around by the channel the distance is from 5 to 8 miles. The velocity of the current is greater than in the upper bayou, being from 1½ to 2½ miles per hour. The width of the bayou varies from 100 to 200 feet, and in depth, except at the fords and shoals, from 5 to 9 feet, though in many cases the pools below the shoals show a depth of upwards of 20 feet, which is characteristic also of the Ouachita.

In addition to the 18 fords in this stretch, where the depth varies from 1½ to 3 feet, the obstructions to navigation consist of wrecks, snags, logs, and leaning timber.

IMPROVEMENTS AND ESTIMATES.

For the improvement at the present time, it is proposed to cut down the leaning timber and remove the wrecks, snags, &c. The working season would be from July to December, at which time the bayou would be sufficiently low to allow the work to be done economically. The out-

fit would consist of a flatboat, with the necessary machinery and outfit of tools, &c., for removing the obstructions from the bed of the stream, while an extra party could be employed on the banks, cutting the leaning timber. In the upper part of the bayou, where the current is somewhat sluggish, this timber would have to be disposed of on the bank and not be allowed to fall into the river.

ESTIMATES.

Outfit:	
Flat-boat	$1,000 00
Engine	900 00
Tools, rigging, &c	500 00
Repairs and incidentals	300 00
Total	2.700 00
Labor, &c.:	
1 assistant engineer, per month	150 00
1 foreman, per month	100 00
1 engineer, per month	90 00
1 cook, per month	60 00
18 laborers, at $60 per month	1,080 00
Subsistence	330 00
Total for one month	1,810 00
Total for 12 months, two seasons	21,720 00
Cost of outfit	2,700 00
	24,420 00
Contingencies, 10 per cent	2,442 00
Total estimate for improvement	26,862 00

It is possible that good labor may be procured at a price less than named in the estimates, but the work must be conducted at a season when labor is needed for picking cotton and at which good wages can be made. During the past season the roustabouts on the lower-river steamers received $90 per month, and in some cases demanded and received as high as $110.

COMMERCIAL STATISTICS.

Average products per season:		
Oak staves carried on flat-boats	180,000	
Oak staves carried on steamboats	12,000	
Total		192,000

Cotton.

Principal shipping points and number of bales:

Baxter station to State line:

Baxter station	*2,000	
Durmont	*2,000	
Oakland	*1,500	
Poplar Bluff	3,000	
Erie City	500	
Intermediate landings	5,000	
		14,000

From State line to Ouachita City:

Line	10,000	
Linn Grove	1,500	

* Carried by rail to Mississippi River.

Bastrop and Point Pleasant	10,000	
Cotton from the hills	6,000	
Intermediate landings	4,000	
		31,500
Total		45,500

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

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EXAMINATION OF TENSAS RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 1, 1880.

GENERAL: I have the honor to present the following report upon the examination of Tensas River, Louisiana, with estimated cost of removing obstructions from same, in accordance with act of Congress approved June 14, 1880.

The bayou was examined from its headwaters near Lake Providence to its junction with the Ouachita River at Trinity, Louisiana, a distance estimated at 256 miles. The party in the field was under the charge of Mr. H. C. Wilson, assistant engineer, whose report will be found annexed.

The improvement considered necessary to be made at the present time contemplates the removal of the obstructions to navigation consisting of snags, logs, and leaning timber. The extreme upper section of the river, from the headwaters down to the crossing of the Vicksburg, Shreveport and Texas Railroad, is so filled up with these obstructions, and the cost of making a navigable channel is so great, when compared to the advantages to be gained commercially, that I have not deemed it necessary to consider that section.

Mr. Wilson estimates the cost of improving the river from the mouth to the Westwood place, a distance of 92 miles, at $13,722.50. Boats before the war ran to Dallas, at the railroad crossing, a further distance of 88 miles. I think the improvement might with advantage be continued to that point, giving increased facilities for the shipment of the crops. The total cost of the whole work I estimate at $23,000.

The amount of cotton shipped from the bayou annually is estimated at 10,000 bales, valued at $500,000; in addition to about 70,000 sacks cotton seed.

As mentioned in the report on Bayou Maçon, the Tensas lands are liable to inundation from the breaks in the front levees on the Mississippi River; were these breaks closed up and the bayou improved, there would result a greatly increased acreage, and increase in the amount and value of the crops.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. WILSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., October 29, 1880.

MAJOR: I have the honor to submit to you my report upon the examination of Bayou Tensas, Louisiana, which I made under your direction.

Bayou Tensas heads in Lake Providence, and with a small bayou called Baxter's Bayou is the only outlet to this lake. It is situated in Carroll Parish in the northeastern portion of Louisiana. The lake derives its supply of water from a small stream called Jack's Falls, and the drainage of the surrounding country. The general direction of Tensas is southerly and gradually diverging from the Mississippi River. During its course it flows through Carroll, Madison, and Tensas parishes, and borders Franklin and Catahoula parishes on the west, and Concordia Parish on the east. It finally empties into the Ouachita River, opposite Trinity. The junction of Tensas with the Ouachita and Little rivers at this point forms the Black River. I estimate the total length of the bayou to be about 256 miles.

* * * * * * *

I shall divide the bayou into two parts and describe them separately. The first stretch will reach from its head to the present high-water limit of navigation, and the second stretch from the head of navigation to the mouth.

FIRST STRETCH.

Immediately upon leaving Lake Providence the bayou is about 200 feet wide, and remains this width for about half a mile. This width is, however, owing to the artificial canal cut by General Grant. At the end of this half mile it makes a sharp turn to the right and narrows up to 40 feet or less and 10 feet deep. It continues this way for about 3 miles, making several sharp turns to the south and west; it also becomes narrower after each turn until at the end of 3 miles it is but about 12 or 15 feet wide. Here, however, it reaches a very low country and divides into a number of small streams and forms a swamp land, and in some places it would be very difficult to trace the bayou. It continues this way for about 6 miles, when it commences to collect itself, and about a mile further runs into Swan Lake. This is a lake 2 miles long and varies in width from 200 to 400 feet. From the head of the bayou to this lake there are any number of obstructions in the form of snags and timber reaching from one bank to the other, and I found it would be impossible to traverse it, even in a skiff. I, therefore, had my skiff and party hauled by wagon to the foot of Swan Lake, where I entered the bayou.

Swan Lake has another outlet about half way down on the west side—Joe's Bayou, and it is a tributary of the Maçon. Sometimes, however, when Tensas is very low it runs into Swan Lake instead of out of it.

The soil along the bayou is particularly fertile, being of the very dark variety, and I was informed that in a good season it yielded readily a bale and a half of cotton to the acre. Most of it is, at present, lying idle, and tracts which were formerly large plantations are now covered with underbrush. All this is owing to the overflows from the Mississippi, which enters through the Ashton break in the levees, a distance of about 30 miles above. A few of the plantations under cultivation have small levees 2 or 3 feet high, which keep out all except extreme high water. All this portion of the country readily finds a shipping point at Lake Providence, and cotton is even hauled there from Floyd, on the Maçon.

Tensas I found about 120 feet wide at the foot of Swan Lake and about 6 feet deep. There is a ferry, known as Conn's Ferry, here, on the road leading from Lake Providence to Goodrich's Landing. The banks are sloping on both sides, and, I should judge, about 10 feet high; they are mostly composed of a clayey soil with an alluvial deposit on top and an occasional layer of sand. High-water marks, from Misissippi River overflows, I found on almost all the trees; and they indicated that the banks were overflowed to a depth of about 6 feet. About a mile below the lake the bayou had narrowed up to 75 feet, and was about 10 feet deep and pretty straight, and I counted 10 bad snags. The bayou now begins to get very crooked, the width varying from as low as 20 feet to 100 feet. Numerous obstructions in the way of fallen timber, rafts, snags, and drift piles are encountered, and very frequently shoals. These latter are generally found in the straight reaches at the foot of bends. I sounded on all of them, and found from 3 to 5 feet of water; at low-water they would, therefore, be very shallow. There is not much leaning timber, but some would require removal. The current is very sluggish, the bends making the slope of the water surface very small.

The banks are high and covered with heavy timber, which consists of almost every variety growing in that latitude. Oak seems to be most abundant, but the timber is of poor quality. About 6 miles below Swan Lake the bottom consists of clay, and having mixed with it white shells. Thirty miles below Swan Lake a bridge crosses

the stream on the road leading from Monticello, on the Maçon, to Goodrich's Landing, on the Mississippi River. The bayou presents about the same aspect as before described, except that I now began to encounter cypress trees growing in the middle of the stream, and which, with their numerous knees, present formidable obstructions. In many cases I had to cut my way through them. Below the Monticello road the bends are much sharper, and almost all the points in these bends would have to be cleared out.

About 20 miles below the Monticello road a small bayou connects Tensas with Bear Lake. A second bayou, called Roundaway, empties into Tensas about 10 miles below this. From there on Tensas is very straight, and varies from 300 to 500 feet in width, and is from 8 to 12 feet deep until it is crossed by the railroad known as the the Texas and North Louisiana Railroad. This railroad crossing I judge to be, by way of the bayou, about 80 miles from Lake Providence. The clearings of old plantations are frequently to be seen, but none are under cultivation. Some of them are on quite high banks, and seem to be above all except extreme high-water overflows from the Mississippi. I did not see any good timber suitable for rafting along the banks of the bayou, but further back, I understand, are good cypress brakes, and I saw quite a number of rafts waiting to be rafted down at the next high-water.

The railroad spans Tensas by an iron tubular bridge, having one pier in the center of the stream. The bottom is hard, and contains a great many shells. Tensas is about 175 feet wide here and 5 feet deep in the channel.

The place at the railroad crossing is Dallas; there are about 50 inhabitants, 8 houses, and 1 store. The owners are endeavoring to reclaim their places in this vicinity, and on the plantation on the south side of the railroad, owned by a Mr. Weightman, they are building levees about 6 feet in height to inclose the place. A small crop is also being raised, and if it should prove a successful experiment the adjoining places would also, in a short time, be in a state of cultivation. The last crop from the 6 plantations in this vicinity was 400 bales. The charge for transporting cotton to Vicksburg, a distance of only 28 miles, is $2.50 per bale. Before the war, boats ran regularly up as far as the railroad bridge. From the bridge down Tensas is pretty straight—100 to 150 feet wide, and 10 feet deep. Six miles below Dallas, at Quebec, the bayou and railroad again meet, but do not cross. There is but a single house at Quebec. Very long horseshoe bends are now encountered, some of them being 15 miles long and only from $\frac{1}{2}$ to 1 mile across the neck.

The Carter place, 1,280 acres, is 4 miles below Quebec on the same side of the bayou. About a mile further, on the opposite side, is the Hester place, 1,734 acres. Both the Carter and Hester places have good facilities for shipping any crop they might produce, but all are lying idle or given up to stock-raising, owing to the heavy overflows. A small levee of about 3 feet in height would soon reclaim these places, but there seems to be a disinclination on the owners' part to spend any money. There are some droves of cattle numbering as high as 500 head, and they readily find a market in Vicksburg during the fall and winter. There are several shoals in this vicinity with about 3 feet of water. The bottom is more sandy. The timber on the banks, which are high and sloping, is mostly composed of willow. Very frequently the bayou for sometimes a couple of miles will be full of long grass, which only grows on a sandy bottom. I noticed that, as a general thing, whenever the banks were covered with either cypress or willow, the bed of the stream was more apt to be full of snags and logs. Not long before I made this examination a hurricane had passed over this section of the country and had blown a great deal of timber into the bed.

The Sharkey place is the next one of any importance, and is 25 miles below Hester place. A small portion of it is being cultivated this year. A long bend, known as the Disheron's Bend, reaches almost around this place. It then reverses into an equally long one and borders the Marshall place, 18 miles from Frisby's.

Fool's River, an inlet of about 4 miles in length and 500 feet wide, without any current whatever, is 9 miles below the Marshall place. It is so called, as during high-water it has often misled pilots.

The next bend after the one bordering the Marshall place is known as Frisby's Bend, and borders the plantation of the same name. It is very full of snags and logs.

The Frisby place is the largest along the stream, containing 23,000 acres. It has a large steam-gin, saw-mill, and grist-mill combined, a dwelling-house, and numerous quarters for hands still standing. If it were not for the Mississippi River overflows this would be a flourishing place. Should these overflows be prevented it would take but very little to put the place in running order. Thirteen miles below this is the Westwood place, the present head of navigation, and the end of my first reach.

The bayou from Swan Lake to the Westwood place presents very little difference in appearance. It alternately narrows and widens, shoals and deepens, and the obstructions are of about the same nature, snags, logs, shoals, and towheads. Little or no land is being cultivated except in the vicinity of the railroad, which affords it a good outlet for its crops. The stock raised can also be easily driven to the railroad.

I can therefore not see any advantage to be derived, at present at least, by the improvement of the stream above the Westwood place.

* * * * * * *

SECOND STRETCH.

This stretch reaches from the Westwood place to the mouth, and is navigable during high-water, the last trip having been made that far up last February. The boats, however, ran up to Mound Bayou as late as last April.

The Westwood place consists of 1,500 acres, a portion of which is being cultivated. It has a fine gin, dwelling-house, and quarters. They expected to raise 15 bales of cotton this season. The bayou is from 75 to 120 feet wide there; and several shoal places both above and below are encountered. A small bayou called Mill Bayou comes in on the left bank, about 4¼ miles above Westwood place. The next place is the Buckner place of 4,000 acres, and at a distance of 5 miles from the Westwood place. This place also has a fine gin, dwelling-house, and quarters.

The banks on this portion of the stream are still high and sloping, and I estimated their height from 15 to 20 feet. The bottom seems to be mostly composed of sand, but occasionally you meet with clay.

Mound Bayou, 12 miles from Buckner's, is the second town on the river. It has several stores, a post-office, and about 10 dwellings, and directly opposite on the other side there are as many more. The country around here is more open and more land is cultivated. They claim to ship from there 1,000 bales a year. Most of this is shipped by boat, two packets running regularly in this trade in high-water season, and making 12 trips each. Some of the cotton is also hauled to Hard Times Landing, on the Mississippi, a distance of 22 miles. Most of the down freight comes in that way.

The Walker place, of 1,200 acres, is the next place, and distant 4 miles from Mound Bayou. Tensas here takes a sharp turn from its course, which was westerly, and goes due south. There is no plantation now until the mouth of the Maçon is reached, a distance of 30 miles. This portion is called the Wilderness. It has high sloping banks on both sides, lined with heavy timber. The banks seem to be mostly of hard clay, having a great number of shells embedded in them. In this stretch the bayou is very winding, and after each bend it seems to widen out, and towards the lower end it resembles a series of lakes. The tops of the banks seem to be covered with the same alluvial deposit as found above. High-water marks I found varying from 2 to 6 feet above the surface of the ground. Before the Maçon empties into Tensas the latter widens out into a shallow lake about half a mile wide and several miles long. There are shoals at both ends and very near the center, where a small stream called Big-a-Planty Bayou, empties into it. The bottom of this lake is of hard clay, containing shells and also sand, and several small islands are formed.

Kirk's Ferry, 5 miles below mouth of Maçon, is the third town and post-office. It has two stores and several dwellings. Just above Kirk's Ferry is a second inlet also, called Fool's River, similar to the first. Choctaw Bayou, which is navigable at high-water, flows into Tensas immediately opposite Kirk's Ferry. About 1,000 bales of cotton is shipped in a year from this place, part of which goes down Tensas on boats, and the remainder is hauled to Waterproof Landing, on the Mississippi, a distance of 20 miles.

The distance between Kirk's Ferry and Trinity is 36 miles. The bayou between these points is pretty straight, and affords good navigation in any except extreme low-water. From bank to bank it varies from 200 to 300 feet. The banks are high and sloping on both sides, and consist principally of clay, with some sand. The height gradually diminishes towards the Ouachita. The bottom is mostly composed of sand, with an occasional clay lump cropping up in the stream. There are numerous plantations on both banks, which yield very good crops; at Trinity I was told the total amount of cotton raised along the bayou would amount to 10,000 bales.

I obtained a list of all the shoals between Kirk's Ferry and Trinity, and sounded them as I went down, and they are as follows, with the depths found:

Shoals.	Distance from Trinity.	Depth.	Width.	Remarks.
	Miles.	*Feet.*	*Feet.*	
Alphenia Landing	33	7	150	Extend 30′ to 40′.
O. K. Landing	28	7	220	¼ mile long.
Kimball's Bayou	24	6	250	½ mile long.
Frenk's Bar	18	3½	175	½ mile long.
Cash Bayou	13	4½	175	
Brushy Bayou	10	4½	200	

The worst of these is at Frenk's Bar, and would require quite extensive dredging for very low-water. These soundings must be diminished 2 to 3 feet for low-water. Between Brushy Bayou and the mouth the river is rather difficult to navigate. Very frequently clay lumps occur in the middle of the channel. The current is also very much swifter than I found at any other place. On my way down I met the steamboat W. C. Flanders, on her way up to Kirk's Ferry. There she intended taking a load of seed and cotton, and come out with the first rise.

The backwaters out of the Ouachita, I was told, extended generally as far as Kirk's Ferry, and have been known to reach as high as Mound Bayou. During several low-water seasons of Tensas, boats have been able to run up on these backwaters.

There are no levees along the banks of Tensas at all. One or two plantations are inclosed by private levees. In extremely rainy seasons this closing the plantations entirely in is almost as bad as an overflow, for all the rain that accumulates has no outlet whatever. I made several inquiries as to whether a complete set of levees had existed, but could not learn of any.

The following table will give distances, width, depth, nature, and amount of obstructions between the mouth and Westwood Place:

	Distance.	Width.	Depth.	Snags.	Logs.	Leaning timber.
	Miles.	*Feet.*	*Feet.*			
Westwood Place	92	100	12	.....	.....	.....
Buckner Place	87	100	10	60	35	.....
Mound Bayou	75	175	15	70	40	100
Walker Place	71	150	12	100	25	.....
Macon	41	(*)	½ to 6	.....	.....	.....
Kirk's Ferry	36	175	14	.....	.....	.....
Mouth	.....	200	12	500	70	.....
Total	92	.....	.....	730	170	100

* One-half mile.

There are several tributaries in this reach and are named as follows: On the right bank—Cross, Roaring, Big-a-Planty, and Ha-ha; on the left bank—Roundaway, Glade Mound, Bielers, Choctaw, Black, Little Tensas, Kimball's, and Brushy. Of these Choctaw and Little Tensas are navigable at high-water.

High-water mark I found all along the bayou and about 20 to 25 feet above surface of water.

Cotton is the principal product, and it is estimated that 10,000 bales of cotton and 70,000 sacks of seed come out of Tensas. Corn, wheat, and other products necessary for home consumption, are also raised. This, with stock-raising and rafting, includes all exports.

To render low-water navigation possible would require the expenditure of a greater amount of money than would be warranted; besides, the low-water season occurs before the crop is ready to be shipped, and boats would not find business enough to pay for the trip. A great saving in freight charges would be effected should the river be improved—at least 75 cents to $1 on each bale of cotton. If boats were enabled to run regularly, a great deal more land would be cultivated, as planters could depend on getting their crops to market regularly.

My estimate is made for a stage of water about 3 feet above low-water; this would enable boats to run about 8 months out of the year, if desired.

The logs and snags can be removed by a light-draught snag-boat, say of from 15 to 18 inches draught.

The clay lumps I think are sufficiently solid to be blasted apart, and the pieces can be readily removed with picks. In Tensas Lake a little dredging might be required.

ESTIMATE OF COST.

Cost of working party for one month:

Engineer in charge	$150 00
Mate	100 00
Engineer of boat	100 00
20 men, at $40 per month	800 00
Subsistence 23 men, at 50 cents per day	345 00
Total	1,495 00

Building light-draught snag-boat	$3,500 00
Snag-boat 5 months in field, at $1,495	7,475 00
Tools and repairs	500 00
Removing clay lumps	1,000 00
Contingencies, 10 per cent	1,247 50
Total	13,722 50

Very respectfully, your obedient servant,

H. C. WILSON,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

P 31.

EXAMINATION OF BAYOU MAÇON, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 1, 1880.

GENERAL: I have the honor to transmit herewith a report upon the examination of Bayou Maçon, Louisiana, with estimates of cost of improving same, made in accordance with act of Congress approved June 14, 1880.

The examination was made by Mr. F. S. Burrowes, assistant engineer, and extended from the headwaters of the stream, in Desha County, Arkansas, to its junction with the Tensas River in Louisiana.

In presenting the estimates for the improvment of the Maçon, I have not deemed it necessary to consider the upper section of the stream, extending as far down as Floyd, La., a point some 40 miles below the State line, from the fact that this section is so filled with snags, logs, stumps, and other obsbructions that scarcely a skiff can be got through it, and the cost of making a navigable channel will be so greatly in excess of any benefits likely to be derived from its improvement. In addition, the proximity of the Mississippi River, to which the crops can be hauled, is likely to render the improvement unnecessary. I will, therefore, only consider the river from Floyd, the present head of navigation, to the mouth.

The examination showed that, like all streams in that section of the country, the main obstructions to navigation are snags, sunken logs, and leaning timber, the removal of which will constitute the principal work to be carried on with a view of improving the stream and of giving increased facilities for the shipment of cotton and the return of plantation supplies and other freights. Were any other system of improvement carried on, it would have to be by a system of locks and dams, which the commerce of the adjacent country would not at present justify.

Floyd is the only town on the Maçon. It is the county seat of West Carroll Parish, and contains about 250 inhabitants. The amount of cotton shipped from this point is said to be 3,000 bales. It is the present head of navigation, boats running regularly to the place about 5 months in the year. Some of these make round trips to and from New Orleans; others connect at Trinity with the Ouachita River boats.

The amount of cotton shipped from the bayou by steamer amounts to about 9,000 bales annually. Other amounts go by way of the Vicksburg and Shreveport Railroad to Delta, and thence by boat to New Orleans. Were the bayou improved, the running time of the steamers would be

increased about three months, and nearly all the cotton raised would find an outlet through the river at reduced rates of freight.

The lands through all this section of Upper Louisiana are susceptible of a high degree of cultivation, but the breaks in the levee along the Mississippi front in Arkansas, while doing no particular damage to that State, cause the lands in North Louisiana to be inundated every high-water. Were these breaks repaired, all the now abandoned lands in this section of the State would be brought under cultivation. This work, combined with the improvement of the streams like the Bœuf, Maçon, and Tensas, which would facilitate the shipment of the crops, would add greatly to the production of cotton and other crops.

The estimated cost of removing the obstructions from Bayou Maçon is $16,995.

The report of Mr. Burrowes, giving all the details of the examination, is annexed.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. F. S. BURROWES, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 11, 1880.

MAJOR: In compliance with your instructions of October 3, I have made a personal examination of Bayou Maçon, Louisiana, in a skiff, from near its headwaters to its mouth, and herewith offer the following report of its present condition and probable cost of improvement.

The bayou heads in the lower portion of Desha County, Arkansas, thence runs through Chicot County, and enters Louisiana, forming the dividing line between East Carroll and West Carroll parishes. It then divides Madison from Richland, enters Franklin Parish, and flowing through its entire length enters Bayou Tensas at a point about 40 miles above Trinity, at its mouth.

On the right of the Maçon, from near its origin to within a few miles of its mouth, a range of low hills, composed of a hard ferruginous clay, covered with about 1 foot of alluvial soil, follows the bayou closely. These highlands, generally known as the Maçon Hills, are about 15 or 20 feet above high water, from 20 to 25 feet above the surrounding bottom lands, and from 5 to 10 miles wide. Being entirely free from danger of overflow, and the soil being rich enough to yield fair crops, these hills are very generally cleared and under cultivation, producing the great bulk of the cotton raised along the bayou. The bottom lands, although much more productive, are very little worked, on account of their liability to overflow.

The water in the bayou at the time of the examination, from the best testimony I could obtain from the inhabitants, I judged to be about 2 feet above its lowest stage, and falling, thus affording a good opportunity to observe the snags, logs, and other obstacles to navigation.

For convenience I will describe the bayou in detail in two parts, dividing it at the town of Floyd, and take up the upper portion first.

BAYOU MAÇON, ABOVE FLOYD.

Entering the bayou at Eudora Ferry, 4½ miles west of Grand Lake, Arkansas, on the Mississippi River, I examined it for about 10 miles above and found it about 70 feet wide, 3 feet deep, and so filled with snags, sunken logs, and large cypress stumps as to make it almost impassable with a skiff. From this point to its source is quite a long distance, but it is so narrow, shallow, and filled with obstructions that its improvement would be impracticable, and, from its close promixity to the Mississippi River, unnecessary.

Coming back to Eudora Ferry, and floating down, I found the distance to Floyd to be 70 miles by the bayou, and its general characteristics about as follows:

At Eudora Ferry the stream is 75 feet wide and continues this width with an average depth of 5 feet for about 10 miles, bending only at long intervals. At the end of this portion an island or bar 300 feet long has formed, which leaves a channel on either side 30 feet wide and 2 feet deep. After this is passed the bayou again assumes the same width and general lake-like character as above, and continues thus for a distance of 5 miles, when it becomes very crooked, narrow, and shallow. Down to this point there are about 20 large snags to the mile, besides a great number of sunken logs and several oak and gum trees stretching clear across the channel. The timber along this portion, composed of oak, hickory, gum, and pecan, is dense and continuous, and, owing to the narrowness of the channel, forms an obstacle which would have to be removed to make it navigable. The bayou then continues crooked, narrow, and shallow as far as Nash's Ferry, 35 miles below Eudora Ferry. This portion is filled with snags and sunken logs, which collect in the bends and form impassable rafts from 200 to 300 feet long. The timber along the banks also changes in character, becoming largely heavy cypress, which leans over the bayou, and which, together with the numerous large stumps of the same timber found in the channel, forms formidable obstacles to its improvement here.

Fifteen miles above Nash's Ferry and 4 miles below the line between Arkansas and Louisiana the Maçon is crossed by a road leading to Ashton Landing on the Mississippi River, which is only 2½ miles distant from it at this point.

Below Nash's Ferry the bayou widens to 150 feet, has a depth of 6 feet, is nearly straight, and singularly free from obstructions, both in the channel and on the banks. It continues thus for 15 miles. From this point to Floyd, a distance of 20 miles, it again becomes very crooked, narrow, and shallow, being only 100 feet wide and from 2 to 4 feet deep. The leaning timber on this reach, which it would be necessary to cut in order to make the bayou navigable, is very heavy and thick, without, however, including much cypress. The snags in the channel are very numerous, averaging about 25 to the mile, and the bed of the stream is a perfect network of sunken logs. These obstructions, along with a very swift current, make this portion difficult to navigate even in a skiff.

The bed and banks of the bayou above Floyd are composed of the same hard red clay as the Maçon hills, covered with from 3 to 5 feet of rich alluvial deposit. The banks are very uniformly 22 feet in height, and overflow from 6 to 8 feet at time of high-water in the Mississippi.

There are a number of small tributaries to the upper portion of the Maçon, none of which, however, are of much importance. The largest are the following: Ditch Bayou, an artificial channel connecting the bayou with Lake Chicot, Arkansas; Rush Bayou, entering the Maçon at Eudora Ferry and connecting it with Grand Lake, Arkansas; Rowen Bayou, entering at Ashton Ferry and connecting the bayou with the Ashton break in the levees on the Mississippi River.

The water in the Maçon, I understand, reaches its lowest stages in the early fall, begins to rise about December 1, and remains from 6 to 18 feet above low-water for about eight months thereafter. It never of itself rises sufficiently to escape from its banks, so that as long as the Mississippi levees opposite its headwaters were continuous, the bottom lands could be cultivated without danger of overflow. Since the breaks in the levees at Ashton, Matthews Bend, and Possum Fork, the Mississippi, at time of high-water, pours into and floods this whole section; raises the level of the Maçon 30 feet above its present stage, and in fact turns it into a high-water chute of the main river. For this reason farming along the bayou at the present time, except on the hills, is precarious and generally unprofitable.

In my opinion it would be inexpedient to attempt to make navigable any portion of the Maçon above Floyd, as, from the number and nature of the obstructions and the narrowness and shallowness of the channel, the expense of such improvement would be very great, and largely in excess of the benefits conferred on the country along it, for the following reasons:

First, as stated above, all or nearly all the land under cultivation along this portion of the bayou is on the hills, from all parts of which shipping points can be found within a reasonable distance, either at landings on the Mississippi or at Floyd on the Maçon.

Second, the improvement of this part would not increase the acreage under cultivation in the bottom lands, as they remain unimproved, not from want of a convenient shipping point, but, as stated, from their liability to overflow by the Mississippi.

BAYOU MAÇON, BELOW FLOYD.

Floyd, the only town on the Maçon, contains 250 inhabitants, and is the county seat of West Carroll Parish, Louisiana. It has 8 stores, a large steam-gin and sawmill, and, it is claimed, handles 3,000 bales of cotton yearly, most of which is shipped down the bayou by boat. It is the present head of navigation; boats running regu-

larly to this point for five months in the year, beginning generally in the latter part of December and making the round trip from New Orleans in two weeks. There is seldom more than one boat at a time in this trade.

The following table shows the principal landings, distances, widths, number and approximate position of snags and sunken logs to be removed, and miles of bank to be cleared of leaning timber, in order to make the bayou navigable below Floyd at any stage of water 4 feet above that found during the examination. The leaning timber is given in linear miles of bank, as from its nature, being mostly young, very dense, and growing down to the water's edge, it would be impossible to give an intelligent idea of its extent otherwise.

TABLE.

Landings.	Bank.	Distance.	Width.	Number of snags.	Number of sunken logs.	Leaning timber.
		Miles.	*Feet.*			*Miles.*
Floyd	Right	130	150	.....	.....	.....
Monticello	Left	124	200	30	16	.....
Epps's	....do	120	200	12	6	
Lyons's	Right	117	250	8	8	.....
Shuwalter's	Left	112	300	20	16	.....
Purvis	Right	106	200	75	14	1½
Texas & Northern Louisiana Railroad	.....	100	150	75	18	1
Scott's	Right	95	100	60	22	2
Brim's Ferry	....do	89	350	50	5	.....
Campbell's	....do	85	300	20	10	.....
Roanoke Bend	Left	80	150	45	16	4
Chesterfield	....do	70	100	90	32	.....
Warsaw	Right	68	250	20	12	.....
Montgomery's	Left	66	200	20	8	1
Crockett's Point	Right	60	150	60	36	3
Egypt	....do	45	250	96	42	4
Brandon	....do	42	200	15	12	.....
Talbot's	Left	36	100	75	32	.....
Dixie	....do	28	150	74	32	4
Oakley	Right	22	100	80	27	2
Cut-off	....do	16	150	75	23	2
Bend Emma	....do	8	200	100	32	3
Mouth	.....	.....	150	90	29	2
Total	.....	.....	.....	1,190	448	30

The bayou opposite Floyd is but 2½ feet deep and continues shoal and crooked for a distance of 5 miles, where it widens out into a sluggish lake, 6 to 10 feet deep, with straight stretches 2 to 3 miles in length, and continues thus to Shuwalter's. From here to Brim's Ferry its course is very crooked and the current very swift, with shoals not more than 2½ to 3 feet deep in the sharp bends. The leaning timber from Floyd to this point is mostly young and composed of hickory, gum, oak, pecan, and willow, with some little cypress. It grows down to the water's edge and in the bends forms the most formidable obstacle to navigation. The main banks here are steep and generally 25 feet high, overflowing 4 feet in years of extreme high-water.

The composition of the bed and banks changes entirely between these points. A short distance below Floyd sand begins to show itself beneath the clay, and a little farther down the clay disappears entirely, leaving the bed and banks of the stream composed of compact sand, with a covering of 4 or 5 feet of alluvial soil, and it continues of this character to the mouth of the bayou.

Below Brim's Ferry the Maçon is of a lake-like character, 300 feet wide, 6 feet deep, and nearly straight for about 6 miles, with few obstructions. It then again becomes crooked and shallow, with numerous snags, and the leaning timber in the bends, which obstructs navigation, very dense as far as Roanoke Bend. From Roanoke Bend to Chesterfield there are several long horseshoe bends in which the channel is 150 feet wide, about 4 feet deep, and is fringed with light leaning timber, mostly willow, which a great part of the way interferes with navigation and would have to be cut. In front of Chesterfield it shoals to 2½ feet and continues thus 1 mile, when the depth increases to from 5 to 7 feet, and the bayou is then comparatively straight to a point just above Crockett's. Here a slide of the right bank has made a narrow shoal 3 feet deep, where a number of snags and logs have lodged. From Crockett's Point to Dixie the bayou is not so crooked as above, the bends being long and the current sluggish. The depth of water is usually from 5 to 7 feet, with the exception of the sharp bends, where it

invariably shoals to 2½ or 3 feet. From Chesterfield to Dixie the Maçon is lined most of the way on both sides by old plantations, which are either entirely abandoned or worked on a very small scale, so that the leaning timber, although dense, is generally young, a large part of it being willow.

From Dixie to the mouth the stream is generally very crooked, the snags and logs very numerous and large, and leaning timber, consisting of oak, hickory, gum, cypress, and willow, much heavier and more expensive to remove than above. There are a number of shoals on this part, 2 to 3 feet deep, rendering it fordable every 3 or 4 miles. The current here is also much swifter than above, with the exception of one sluggish lake, 3 miles in length, just below Bend Emma.

The Maçon empties into Bayou Tensas at a point where the latter stream spreads out into a shallow lake about one mile wide.

The general character of the banks on the lower portion of the bayou is the same as above, being 25 feet in height, and overflowing from 3 to 5 feet by the water escaping through the breaks in levees along the Mississippi opposite the headwaters of the Maçon.

The only important tributary entering below Floyd is Joe's Bayou. Its source is about 15 miles above Floyd and is connected near this point with both the Maçon and Tensas at high-water. It then pursues a course about midway between these bayous, emptying into the Maçon at Brim's Ferry, and having a width of about 75 feet at its mouth. From Monticello to the mouth of Joe's Bayou the left bank of the Maçon is high and overflowed only at times of extreme high-water, so that the land along it could be, and a portion of it is, protected by levees 3 feet in height.

The Texas and North Louisiana Railroad crosses the bayou between Purvis's and Scott's, on a drawbridge which leaves a channel span for boats 50 feet in width. Delhi, on this railroad, is about 1½ miles west of the bridge and is at present the shipping-point for most of the cotton made on the Maçon Hills in its vicinity.

The landings on the right bank as far down as Cut-off are at places where the hills come down to the bayou, and thus are shipping points for a large section of country back of them.

At Cut-off Landing there is a high-water connection with the headwaters of Deer Creek, by which at times the water of the Maçon escapes to the Ouachita River. The section of country from here to the mouth of the Maçon, and bounded on its other sides by Deer Creek, Ouachita River, and Bayou Tensas, is known as Sicily Island. It is generally low, a part of it being submerged at time of high-water.

The section of country between Floyd and the mouth of the Maçon is said to ship yearly by boat 9,000 bales of cotton. This amount of course varies greatly with the time navigation opens. In case the season is late the planters, finding it desirable to turn their crops into money, haul long distances either to the Mississippi River or to points on the railroad, thus getting most of the cotton out of the country before the boats begin to run. The increase is of course proportional if the season is early. Carrying cotton, cotton-seed, and corn out, and the necessary planters' supplies in, is about the only traffic of the boats running in the Maçon.

As stated above, the obstructions given in the table are only those which would interfere with navigation at a stage of water 4 feet above that found during the examination, and the estimate given is based on the opening of navigation at such a stage.

This would open navigation to Floyd at least one month earlier, would continue it two months longer, and render it much more secure at all times than at present. Such improvement would cause all or nearly all the cotton raised on the hills to be shipped by boat, and would very likely largely increase the acreage under cultivation in the bottoms, as early and safe navigation would render it profitable for individuals to protect their land.

This is all I would recommend to be done, as to undertake to make the Maçon navigable at low-water would, on account of the great number of shoals, sunken logs, and low-water snags, require an immense outlay, and could not be accomplished at all without some very expensive system of dams and locks.

ESTIMATE.

Expense of snag-boat and crew for one month:	
Engineer in charge	$150 00
Engine driver	60 00
Cook and cabin boy	60 00
Twenty-five men, at $35 per month	875 00
Subsistence 29 men, at 50 cents per day	435 00
Fuel, oil, waste, &c	150 00
Total	1,730 00

Cost of light-draught snag-boat	$3,500 00
Five months' work for snag-boat	8,650 00
Three months work for chopping party, consisting of 20 men and foreman	3,300 00
Contingencies, 10 per cent	1,545 00
Total estimated cost of improvement	16,995 00

This work can only be done to advantage at a very low stage of water. The snag-boat estimated for is therefore a light flatboat, having steam drum and quarters for men, and should not draw more than 18 inches of water.

Respectfully submitted.

F. S. BURROWES,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Engineer Corps, U. S. A.

P 32.

EXAMINATION OF CURRENT RIVER, FROM VAN BUREN, MISSOURI, TO ITS MOUTH IN ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 1, 1880.

GENERAL: I have the honor to submit the following report upon the examination of Current River, Missouri, made in compliance with the of act Congress approved June 14, 1880, and assigned to me by department letter of June 17, 1880.

An examination of this stream was made in 1871 by Mr. A. H. Blaisdell, under the direction of Lieutenant-Colonel Raynolds, and upon the report then rendered an appropriation of $5,000 for the improvement of that portion of the stream in the State of Missouri was made by act of Congress approved June 10, 1872.

Having an assistant, Mr. George R. Wilson, at work on Black River, Arkansas, into which Current River empties, I directed him to proceed to Van Buren, Mo., and to make a thorough examination of the river from that point to its junction with the Black. From this examination and from the report above alluded to, sufficient data have been obtained upon which to base estimates for the improvement of the stream.

Current River has its source in Texas County, Missouri. It flows through Shannon, Carter, and Ripley Counties, Missouri, and Randolph County, Arkansas, and discharges into Black River (a branch of the White) a short distance above Pocahontas. It has a number of small and unimportant tributaries, the drainage area of all combined being estimated at about 2,000 square miles. During ordinary stages of the river these tributaries furnish about two-thirds of the volume of water in Current River, the remaining one-third coming from a large spring some 30 feet in diameter, situated about 7 miles below Van Buren. According to Colonel Raynolds, a rough gauging of this spring showed a discharge of over 500 cubic feet per second.

The length of the river by the channel from Van Buren to its junction with the Black is estimated at 117 miles. The width varies from 150 to 250 feet, except in a few narrow places. The oscillation of the river between high and low water is about 13 feet.

Steamboats navigating Black River ascend Current River usually only some 30 miles, though at times they go as high as Jones's Ferry, 80 miles above the mouth.

SHOALS AND OBSTRUCTIONS TO NAVIGATION.

From Van Buren to Jones's saw-mill, a distance of 37 miles, there are 38 shoal places, with water over them varying from 0.8 of a foot to 2 feet. The average length of these shoals is about 200 feet. From Jones's Ferry to Doniphan, a distance of 12 miles, there are 6 shoal places similar in character to those in the stretch above. There are also two rapids with water over them from 3.5 feet to 4 feet, the rapids nearer Jones's mill being about a mile long, with a current of upwards of 6 miles per hour, but with good water the entire distance.

From Doniphan to Pittman's, at the State line, a distance of 14 miles, there are 4 shoals and 6 rapids.

From State line to Downing's Ferry, 14 miles, there are 2 shoals and 2 cut-offs. The shoals are very bad, extending entirely across the river, with but 0.8 foot over them at low-water. Of the cut-offs, the upper, called Nelson's Chute, is 1,500 feet long, with a fall of over 6 feet, full of logs and trees piled up in all directions. The lower cut-off is about 250 feet long, with a fall of 3 feet, and also full of logs, &c.

From Downing's Ferry to McElroy's, a distance of 28 miles, the river is a clear, open stream, almost free from snags, shoals, and rapids, and with water in no place of a depth less than 6½ feet. Nothing exists in the way of obstructions, except overhanging timber.

From McElroy's Ferry to the mouth, 12 miles, the river is free from shoals and rapids, but full of snags, &c., and the banks are lined with overhanging timber.

PREVIOUS SURVEYS AND IMPROVEMENTS.

In the year 1857 an approximate compass survey was made from Jack's Ford, 37 miles above Van Buren, to the State line.

In 1855 the State of Missouri appropriated $10,000 for the improvement of the stream, but no good seems to have been effected. In 1871 the State made another appropriation of $20,000 for continuing the work.

In 1871 an examination, with a view to the improvement of the river, was made under the direction of Colonel Raynolds. Upon the report then rendered, Congress, in 1872, appropriated $5,000, which was expended upon that portion of the river above the State line, in building dams, removing snags, and cutting down overhanging timber.

COMMERCIAL STATISTICS, &C.

Carter County, of which Van Buren is the county seat, contains over 450 square miles. There are about 100 small farms, and 400 voters in the county. The amount of wheat raised in the county is about 12,000 bushels, corn 36,000, most of which is for home consumption. The only article of export seems to be pine lumber, which is floated out in rafts from above Van Buren.

Ripley County embraces an area of over 600 square miles. There are about 550 farms, raising 55,000 bushels of wheat, 110,000 bushels of corn, and a small crop of cotton.

The county seat, Doniphan, would command quite a large trade, if the navigation were good, as all the products of Oregon and Howell Counties (which are each one-third greater than Ripley) would pass down the river, instead of over bad roads to the railroad at Pocahontas or Poplar Bluff.

The country along the river in Arkansas is well settled on both sides for a short distance back, but on account of the insufficiency of water transportation, the inhabitants are compelled to ship their products to Corning or Pocahontas. At present the lumber interest seems to be the important one of the region traversed by the river.

Numerous saw-mills are along or near the stream, and it is estimated that upwards of 1,000,000 feet of lumber and 500,000 feet of logs are rafted out annually.

IMPROVEMENTS PROPOSED.

On that stretch of the river from Van Buren to Jones's Ferry, 37 miles, it was formerly proposed to build dams at the shoal places, so as to confine the water to a single channel, and the inhabitants desire this method of improvement to be carried out. This would undoubtedly give good water, but it is probable that no steamboat likely to navigate the river could ascend.

The river takes its name from the rapidity of its current.

The appropriations made by the State of Missouri, and by the government, were expended in building dams at the heads of the islands forming the shoals, so as to concentrate all the water in a single channel, but the first rise following took everything out; not a vestige of the work remains at the present time. It is not deemed advisable to recommend any improvement of this part of the river. The cost would amount to more than the resources of the country would at present justify.

From Jones's Ferry to Doniphan, 12 miles, the two shoal places can be readily improved by wing-dams of brush and stone at a cost of $750 each. The rapids, having plenty of water over them, need no work.

In the stretch between Doniphan and the State line, the four shoals can be improved by similar constructions as above. Merrill's Shoal, the worst of the four, will cost about $1,200; the remaining three, $600 each.

From the State line to Downing's Ferry the two shoals are very bad, extending entirely across the river. The dikes here will cost not less than $1,200 each. From the improvement of the cut-offs it is deemed advisable not to work in the cut-off directly, but to clear out the old bends of the river, close up the chutes, and force the river to take its old course. The estimated cost of this is $3,000.

From Downing's Ferry to the mouth, the work of improvement will consist in removing snags and cutting down leaning timber along the banks. It is estimated that this work can be done for $200 per mile from mouth to McElroy's, and $100 per mile from McElroy's to Downing's Ferry, or $5,200 for this stretch of the river.

The total amount, as above, will be	$15,100
15 per cent. for contingencies	2,265
Estimated cost of improvement	17,365

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

P 33.

SURVEY OF HARBOR AT GRAND GULF, MISSISSIPPI.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 12, 1880.

GENERAL: I have the honor to transmit herewith a report upon the survey of the harbor of Grand Gulf, Mississippi, and the Mississippi River in the vicinity, in accordance with act of Congress approved June 14, 1880.

The survey was made by Mr. H. St. L. Coppée, assistant engineer, and party, and extended from a point on the Mississippi River at Brooks' Landing, in the bend above Grand Gulf and Hard Times, to the foot of Duke's Towhead, 6 miles below the landing for the Port Gibson Railroad. The total length of the survey was 17 miles. It embraced also the Louisiana shore, and all intermediate land between the upper and lower limits of the survey; the old and new channels; the lower section of Big Black River. Twenty-six cross-sections of the main river and the old and new channels were made, and the slope and discharge of the river were also determined.

By reference to the accompanying map of the survey, the past and present condition of affairs in the vicinity of Grand Gulf can be readily understood.

As late as 1864, it will be seen by the dotted blue line which shows the positions of the Louisiana and Mississippi shore-lines at that date, that the Mississippi, after leaving Hard Times, swept around the bend directly in front of Grand Gulf Landing, giving to that place a good and sufficient depth of water for all navigable purposes. In the bend just above the town the Big Black River debouched into the Mississippi. Changes which took place in the Mississippi above brought corresponding changes in the channel below and in the situation at Grand Gulf. As the eroding action of the Mississippi continued around Hard Times Bend, the filling up in front of the landing and around the Grand Gulf Bend likewise continued; at the same time the bank at the lower end of this bend was being eroded, and caused an accretion to the end of Coffee Point opposite. This eroding and filling up continued down to 1875, at which time an extensive bar had formed in front of Grand Gulf, and the landing had to be moved down to about its present position at the Port Gibson Railroad landing. Big Black forced its way through the deposit, adding some three miles to its length, while Coffee Point, Louisiana, at the same time was extended some considerable distance towards the Mississippi side.

In 1875 the Mississippi River forced a channel across Coffee Point or Neck, which since that time has widened considerably and is now the main channel of the Mississippi River at that place, leaving an island between the old channel and the cut-off, known as Grand Gulf Island.

At the present time the situation at Grand Gulf and vicinity may be briefly stated as follows:

The caving in Hard Times Bend on the Louisiana side has been very considerable, while at the same time an extensive deposit has taken place in Grand Gulf Bend, extending from about a mile below the old landing (*i. e.*, from the present railroad landing), around to Thrasher's Point to the northward, so that Grand Gulf Harbor may be said to have been filled up. The new channel formed by the cut-off through Coffee Neck has widened and deepened to such an extent that, it is now

the main channel of the river; the old channel in the mean time has been partially filled up, the north passage particularly, so that, at an ordinary low-water stage, boats going north and south wishing to approach Grand Gulf Landing are compelled to go and return to the main channel via the channel south of Grand Gulf Island. In high stages of water they can approach the landing by either channel. This filling may continue and result in the complete destruction of the old channel, though judging from the caving of east bank of the main channel along Grand Gulf Island (which is composed wholly of sand), it is possible that the river may so cut into and destroy a portion of this island as to eventually bring the channel back to somewhat near the position it had prior to the cut-off through Coffee Neck.

To restore the landing at Grand Gulf and have the same again upon the Mississippi River, a proposition that has received favor among those particularly interested in the matter is to start on the Mississippi River at some point below Brook's Landing—the head of the survey—and to cut a canal or ditch across the neck, taking in possibly Alligator Lake, and coming out, say, near the present landing. This scheme, which involves also the damming of Big Black, it is supposed, will bring the river back to its old bed near the point of rocks and give to Grand Gulf a permanent harbor.

The stretch of country through which it is intended to lead the ditch is at present but little cultivated, with possibly the exception of the Yucatan place. Otherwise, most of the land is a vast heavily-wooded swamp, unprotected by levees, and entirely overflowed at high-water.

It has been suggested by those in favor of the canal project that it would only be necessary to dig a ditch of small dimensions across the neck, and allow the river to complete the remainder of the work. This is doubtful. Mr. Coppée has estimated for a large cutting, extending in depth below the stratum of blue clay and exposing the sand. The total excavation amounts to 2,392,700 yards, at an estimated cost of $1,054,780. Even this would be of doubtful utility, and the cutting would probably have to be aided by additional works, so as to train the current into the made cut, for, although the head of the proposed ditch is located on a caving bank, its general direction is at right angles to the current of the river. Should the work be executed, it would also be necessary to dam Big Black River, so as to prevent the new channel from taking a direction out through the mouth of that stream. Independent of all the expense attending the engineering operations, there will necessarily, also, be prospective damages, arising from the destruction of private property on account of the cut.

The question may be asked, What is the object of the contemplated work? It is to restore to Grand Gulf its former landing on the Mississippi River, and that only, at a considerable expense. In itself, commercially, Grand Gulf is a place of no particular importance. It was, and the lower landing now is, a shipping point for the products of the country back. It is also the terminal point on the river of the Port Gibson Railroad, this town being distant about 8 miles. According to the best information that could be gathered, the total shipments from Grand Gulf for the twelve months ending August 31, were estimated in value at $837,000. Probably more than two-thirds of the products came over the railroad.

Now, while the proposed change, if made, will benefit Grand Gulf and the surrounding country, it will be a detriment to that portion of Louisiana lying directly opposite, that is, as regards the facility for the shipment of crops, &c. Hard Times Landing is the outlet for the products

of a rich and highly cultivated country back. The total value of the shipments from that place, for the same period as above, was $538,000. Hard Times is situated on a caving bend, and the change would probably be a benefit to that point, but it would cut off the entire surrounding section from its present outlet, and cause the people to seek another landing from which to ship their products.

At the present time, the old channel affords sufficient depth and width for all boats to get to the landing at Grand Gulf, even at the lowest stage of the river. It is, however, filling up gradually, and may continue to do so to such an extent as to be eventually destroyed, except as a high-water channel, if the changes now taking place in the west bank of Grand Gulf Island do not continue, so as to force the channel back to near its old position. By reference to the map it will be seen that the current of the Mississippi River impinges directly against said bank with considerable force, and tends to destroy it. Between March and September it had caved away some 900 feet at its lower end, gradually decreasing up stream, and judging from present indications this caving is likely to continue, with the likelihood as above mentioned.

At all events, should it be desirable for the railroad to secure a landing so as to be able to connect with the steamboats, it would only be necessary to change the direction of their line on coming out of the ravine, and run southward, as shown by the dotted line on the map, instead of northward to the present landing. There are no special difficulties in the way; the grade of the road would have to be kept above high-water mark. This change could be made, and a landing secured at any point on the lower channel, as circumstances would demand, at a cost to the railroad that would be very small in comparison with the amount that the government would be required to expend in making the proposed change, and at the same time the shipping interests of the Louisiana country opposite would not be jeopardized.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 8, 1880.

MAJOR: Having made a thorough examination of Grand Gulf Harbor, Mississippi, during the months of August and September of this year, with the assistance of Messrs. F. S. Burrowes and H. C. Wilson, as you directed, I have the honor to submit the following report, accompanied by a map of the vicinity, profiles, sections, &c.

My first care on arriving at Grand Gulf was to establish a water-gauge at the town landing, and also two others above, which I shall mention hereafter in connection with the slope of the river.

By a comparison of the gauge readings at Natchez and Vicksburg with those obtained at Grand Gulf Landing, I have been enabled to establish the low-water mark of 1872 at this place, which I call the zero of the gauge. This I proved to be practically correct by means of levels run to an established high-water mark of 1867. The oscillation thus determined is 49½ feet.

The accompanying map shows the general features of the river, which I examined in connection with the harbor survey, leaving but little to explain.

All my levels, as stated in a note on the map, can be referred to a bench on the turntable of the Grand Gulf and Port Gibson Railroad, established and used by the Coast and Geodetic Survey March, 1880.

The country lying on the Mississippi side through the entire reach from Brooks's

Landing to the end of Duke's Towhead, is at present very little cultivated, with one exception, that being Yucatan place, which was planted last season by numerous colored men, each making a small crop of cotton. Otherwise most of the country between the hills or bluffs and the river is a vast, heavily-wooded swamp, entirely overflown at high-water, as shown on the map and profiles, and is unprotected by levees, the only remaining signs of an attempt at such protection being the old pieces of Yucatan levee, which at one time relieved that plantation from the evils of an overflow.

The country on the Louisiana side differs from that in Mississippi, in that it is completely protected by levees, the approximate positions of which are shown by a black dotted line on the map.

The land in many places immediately adjacent to the river is overflown, but a short distance back from the bank are levees, which at the time of this survey, were in good order, having been repaired or newly built during the summer.

The soil is, as represented on the map and profiles, of many varieties and combinations—sand and mud bars, buckshot swamps, high deposit banks, &c. By a comparison of the results of 16 different observations, I found, as a general rule, the subsoil throughout the reach, on the mainland, to be composed of the following strata, and lying in the following order: Alluvial sandy deposit on the surface, then buckshot, then a tenacious, tough, blue clay, reaching in places to low-water and below, and resting on sand. These strata differ in thickness and inclination in different localities, but their general order remains the same. In places the surface covering of sand deposit has apparently been washed away, leaving buckshot exposed, but in every instance I found tough, blue clay to exist somewhere between 8 and 16 feet below the surface.

Grand Gulf Island differs from the surrounding high land in that it is composed purely of a sandy deposit, clay and buckshot showing in no instance on the surface or caving sides; this can be readily accounted for by a glance at the old river lines of 1864 (red dotted), taken from a map made under the direction of Admiral Porter in that year.

The bluffs about Grand Gulf are composed to a great extent of friable sandstone and hard-pan; this well might be used in river improvement for sinking mattresses, &c.

The timber throughout the region is valuable; the cypress brakes contain a good quality and great quantity of that wood. The other varieties of timber also found in quantity are oak, hickory, pecan, elm, sycamore, gum, hackberry, cottonwood, and willow, and a scattering of thorn, ash, magnolia, walnut, china, &c. Great quantities of young cottonwoods and willows cover the numerous towheads and bars, as shown on the map.

In 1875 the cut-off, which at present is apparently tending to sever the harbor of Grand Gulf from river communication with the outside world, existed in the form of a canal across Coffee's Neck, when bank full, 400 feet wide by $1\frac{1}{4}$ miles long. The gradual wearing of the water during its high stages, and finally at all stages on this ditch or canal, has at the present date brought it to the dimensions as shown on the map and profiles. The result of the forming of this cut-off is a very gradual filling up of the old main river bed in front of the town of Grand Gulf. This change, as shown by comparing sections sounded in September with those sounded by the Coast and Geodetic Survey six months previous, is very gradual in many places; indeed the tendency has been to scour rather than deposit, as would have been supposed. At the present date the old river, from the mouth of the Big Black to its confluence with the main channel again, has a channel depth in extreme low-water varying from 14 to 30 feet. The channel, as seen by the profiles, has a sufficient width in which to turn and maneuver the largest river boats; at the upper end, though, near Station P, the low-water channel is but 6 feet deep; this channel, which saves considerable distance in approaching the harbor from the north, is unnavigable for the large steamers at a stage of 10 feet on the gauge; this is more due to the great quantity of low-water snags which have settled here than a want of sufficient depth of water. The Big Black River, though a very insignificant stream, as shown by the accompanying discharge table, aids, to a great extent, in keeping open the lower end of the Old River.

The following tables show, respectively, the slope, the discharge, and the changes in slope for changes in the gauge readings.

The slope I obtained by running a line of levels from one end to the other of the reach surveyed, taking the elevations of the water at known intervals and correcting for the reading of the gauge at the time of leveling. The velocities, discharges, &c., were obtained by running floats (such as used by your observation parties in 1879) at mid-depths of the stream over a sounded section a distance of 200 feet. The third table is merely a comparison of the three gauges during the rise and fall of the river in August and September, and their bearing on the slope.

TABLE.

Between stations.	Distance.	Fall.	Slope per mile.	Remarks.
	Feet.	*Feet.*	*Feet.*	
A and C	5,575	0.271	0.255	Main river from Brook's Landing to head of cut-off.
C and E	8,217	0.377	0.242	
E and G	5,351	0.202	0.298	
G and J	6,534	0.336	0.271	
K and N	9,300	0.430	0.244	
V and X	5,182	0.037	0.038	Slope in Old River.
X and Z	4,480	0.032	0.038	
A′ and B′	8,229	0.311	0.200	From foot of cut-off to south end of survey.
B′ and D′	3,830	0.225	0.310	
N and Z	6,000	0.164	0.144	Through cut-off.
C and Gauge 3, Grand Gulf Landing	19,800	1.694	.....	This distance is measured in a direct line.
Big Black, from ferry to Station 12	3,429	0.140	0.213	Taken September 18, meander line.

Table of areas, discharges, and velocities.

Section.	Area.	Discharge per second.	Mean velocity per second.	Remarks.
	Square feet.	*Cubic feet.*	*Feet.*	
I	110,000	285,000	2.60	From Brook's landing to head of cut-off.
III	76,000	285,000	3.75	
V	84,000	285,000	3.40	
VII	59,500	285,000	4.80	
IX	73,500	275,000	3.76	In cut-off.
XVI	7,300	10,000	1.37	Old River.
XIX	32,000	16,800	0.53	
XXV	21,000	16,800	0.80	
Big Black	5,000	6,000	1.20	Big Black.
XIII	76,800	291,000	3.80	Below Whitehall.

TABLE.

Gauge (1) situated opposite Station J, on main river, 19,300 feet above Gauge (2).
Gauge (2) situated on main river, at head of cut-off, 8,500 feet above Gauge (3).
Gauge (3) situated on Old River at Grand Gulf Landing.

Date.		Gauge readings.			Remarks.
		Gauge 3.	Gauge 2.	Gauge 1.	
August	24	12.3	12.3	12.3	A. m.
	24	12.1	12.1	12.0	P. m.
	25	11.8	11.8	11.7	Falling water.
	26	11.5	11.4	11.4	
	27	11.2	11.1	.....	
	28	10.8	.....	.....	
	30	10.1	10.0	.....	
	31	9.7	.....	.....	
September	2	10.2	.....	.....	A. m., rising water.
	2	10.3	10.2	.....	P. m.
	3	10.3	10.3	10.2	Rising water.
	3	10.4	10.4	10.4	
	4	10.6	10.6	.....	
	6	.....	11.4	11.4	
	8	12.7	12.7	12.7	
	9	13.0	13.0	.....	
	10	13.3	.....	.....	
	11	13.7	.....	.....	
	13	14.3	.....	.....	
	14	14.8	14.8	14.9	
	15	15.0	15.1	15.1	
	16	15.2	15.2	15.2	
	17	15.3	15.2	.....	
	18	15.5	.....	.....	

Date.	Gauge readings.			Remarks.
	Gauge 3.	Gauge 2.	Gauge 1.	
September 20	15.3	.....	.....	
21	15.0	.....	.....	
22	14.4	.....	.....	
23	14.2	.....	.....	
24	13.6	13.6	13.5	
25	.....	.....	13.3	A. m.
25	12.5	.....	12.5	P. m. } Falling water.
27	11.7	11.6	.....	A. m.
27	11.5	.....	.....	P. m.
28	11.3	11.3	.....	
29	11.0	11.0	.....	A. m.
29	10.8	10.8	.....	P. m.
30	10.6	10.5	.....	
October 1	10.1	10.1	.....	

This table shows little or no change of the slope between the gauge readings during the time of the above observation, though during the decline of the water a slight diminution might be inferred.

The fluctuation (5.8 feet) was too small to show much variation.

I have marked in black figures on the map the soundings in the cut-off as taken from a map made under the direction of the Coast and Geodetic Survey; these I have referred to the same water as my own soundings for convenience of comparison. It will readily be seen that from the time, in March, 1880, when the former were made, until I sounded the same ground, a considerable change has taken place, in some instances the difference being over 40 feet. In other words during the six months previous to September, the water in the "cut-off" has deepened in places over 40 feet. This change was probably effected during low-water, or the transition from high to low water. The present low-water channel, as per profiles, is as deep as 77 feet. The tendency of the force of the current in this vicinity seems to be to demolish Grand Gulf Island, by impinging on the loose deposit composing its western banks. At every other point in the reach, the caving is very much less. At Hard Times, 60 feet in a year is the average. At Station I, probably 200 or 300 feet in the same time; the bank at Station C also caves considerably; but in no place does it compare with the destruction of Grand Gulf Island, as shown by red dotted line on the map.

Before suggesting any plan of improvement I shall give, to the best of my ability, the general commercial statistics of the principal shipping points and regions which would be affected by any contemplated change.

Grand Gulf, which, in 1850 and later, was a flourishing town of nearly 700 inhabitants, with one of the best harbors on the Mississippi River, contains, at the present time, about 100 people, mostly colored. The produce or business of the town and country off the railroad which connects Grand Gulf with Port Gibson, amounts to nominally nothing. Grand Gulf, though, is the terminus of this Grand Gulf and Port Gibson Railway, which starts in the town of Port Gibson, situated 8 miles inland on Bayou Pierre. Port Gibson, and a great extent of the adjacent country, depend entirely on the harbor of Grand Gulf, or the landing at the river end of the road, for their supplies and means of shipping produce. Should the arm of the river forming the present harbor be closed by a deposit of silt, owing to the sluggishness of the stream, to insure an outlet either the river end of the railway will have to be moved to a new and safe landing, or the river, by engineering skill, returned to its old bed.

It is the idea of the gentlemen who have at interest the welfare of Port Gibson and the rich country which would be ruined without river communication with New Orleans and Vicksburg, and through whose influence this survey wa sobtained, to arrive at the feasibility of cutting a canal from some point near Station C to the old mouth of the Big Black, which it is supposed will carry the river back into its old bed near the Point of Rocks, and give to Grand Gulf once more a good, permanent harbor.

Should this be accomplished the effect would be very detrimental to the commerce of all that country on the Louisiana side bordering on the present river bank between Stations C and N—Lloyd's, Ship Bayou Place, and Hard Times—the latter landing being of great importance to the lands on Lake Saint Joseph, and as far back as the Tensas, which it supplies in low-water. The following are the commercial statistics of the two places, which are the bases of supplies and outlets for the produce of their respective regions, to wit, Port Gibson and Hard Times.

COMMERCIAL STATISTICS.

Port Gibson.

Port Gibson is 40 miles by stage from the New Orleans and Jackson Railway, contains 1,400 inhabitants, and ships for a region within a radius of 30 miles. The railway connecting it with Grand Gulf is of ordinary gauge, has 1 passenger coach, 6 freight cars, 2 locomotives, &c.

For the 12 months ending August 31, 1880, shipped from Port Gibson, 14,512 bales cotton; sacks seed, 18,000; merchandise, $2,000. Received by railway, 6,000 barrels pork, 7,500 barrels flour, 10,000 barrels meal, 16,000 sacks corn, 1,400 hogsheads meat; other merchandise, ———.

Including Grand Gulf and intermediate points on the road:

Total shipped at Grand Gulf, 16,000 bales cotton, at $50	$800,000
20,000 sacks seed, at 60 cents	12,000
Merchandise	2,000
Total received at Grand Gulf	814,000
Merchandise at Grand Gulf, about	23,000

Hard Times.

Hard Times, as stated before, is the shipping and supplying point for all that country lying adjacent to Buck Ridge and Lake Saint Joseph, and in low-water as far back as the Tensas River.

Shipped, per annum, 10,000 bales cotton	$500,000
27,000 sacks seed	16,000
1,500 packages sundries	2,000
Total	518,000
Return merchandise, 40,000 packages, various values	20,000

Had the improvement of this harbor been attempted a few years ago, before the cut-off had arrived at its present dimensions, this work would have been but light and inexpensive; as it is the cost of bringing the river through a canal back to Yucatan Place will be very great, and the absolute permanency of its bed not insured.

The following is a rough estimate of the cost of a canal and temporary works to give it the proper course:

Canal from Station C to Ferry at Big Black River: Material to be removed to sand below strata of blue clay; blue clay about 20 feet thick at upper end; buckshot 10 feet thick at upper end. Dimensions of canal: 26′ × 200′ × 12,000′ in length = 2,310,000 cubic yards of material, in great part clay and buckshot, at 30 cents per yard, including clearing and grubbing. This is a very low estimate, taking into consideration the amount of heavy clearing and tough material through which it is necessary to cut.

Total coast from C to Ferry, $693,000.

From Ferry on Big Black to near Gauge No. 3, Grand Gulf Landing: Dimensions of canal 10′ × 200′ × 9,600′ in length = 71,000 cubic yards of material. This could be removed in great part by dredge-boat from lower end and at a much less cost, being a soft deposit of mud; 71,000 cubic yards, at 15 cents per yard, $10,700.

Should the stratum of clay become deeper at the lower end the cost would be increased by the necessary deeper cut, and *vice versa* should it tend to run out. It will be seen by examining the map that the direction of the current above Station C, and indeed for a great distance above Brooks's Landing is nearly parallel with the Mississippi shore. To come appreciably nearer the direction of the current it will be necessary to change the course and build at least a mile more of canal than the estimates are made for. This, at the same price, 30 cents per cubic yard, would be $351,080.

From C to Ferry	$693,000
From Ferry to Gauge 3	10,700
Extra mile to be added	351,080
Total cost, without dams, &c	1,054,780

The route might be through Alligator Lake, but with little saving, the lake being very shallow.

This amount may be considerably increased by works to turn the channel from its

present course into the new bed, which would have a fall of 0.45 foot per mile. It would also be necessary to dam the Big Black at or near the point of junction with the canal so as to utilize its water and insure against all possibility of divergence from the new channel.

I have probably underestimated this plan of operations both as to the dimensions of the canal and general cost of the work.

I have proposed to cut only to the bottom of the strata of clay, leaving the river to complete the work, whereas it may be found necessary to dig some distance below the low-water mark.

The gentleman who had contemplated this project thought that a small ditch could be made across the neck of land and the river at once would do the rest of the work; the erroneousness of this idea will be seen at once by a slight study of the map and a comparison of even a 200-foot canal with the present bed of the river. It is possible that the river would run through and dig out a water-way were it constructed as per estimate, but very improbable, without great additional expenditure on works, dams, &c., to turn and control the main force of the current.

It will be unnecessary to make a more detailed estimate to show the impracticability of the above project. It might be suggested that works at the head of the cut-off would reclaim the old harbor, but for many reasons, chief among which is the expense, it would be unwarrantable. I would respectfully suggest that as the filling up of the harbor at Grand Gulf is not very rapid and the cutting away of Grand Gulf Island is just the reverse, that by leaving the river to take its own course, at the time it is necessary to look for a new landing one may be found on the main river not a great distance below the present site, and to where the Grand Gulf and Port Gibson Railway could be turned at an expense counting as nothing compared with the vast expenditure inevitable in any other plan that could be suggested.

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Very respectfully, your obedient servant,

H. ST. L. COPPÉE,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
United States Engineers.

P 34.

EXAMINATION OF CACHE RIVER, ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 16, 1880.

GENERAL: I have the honor to present the following report of the results of an examination of Cache River, Arkansas, in accordance with act of Congress approved June 14, 1880.

The field party was in charge of Mr. Zeph Harrison, assistant engineer, whose report is transmitted herewith.

An examination of this same stream was made in 1871, under the direction of Lieutenant-Colonel Raynolds, the report upon which will be found in the Report of the Chief of Engineers for that year, page 354.

No appropriation, however, was made at that time for work considered necessary to be done in order to open up the stream to navigation.

The length of the stream examined by Mr. Harrison was 250 miles, extending from Martin's to its junction with the White. The upper portion as far down as Gray's Ferry showed no well-defined channel; in fact it was more like a swamp filled with fallen trees, stumps, &c., and through which it was very difficult to pass even with a skiff.

From Gray's Ferry to the mouth, a distance of 160 miles, a well-defined channel was found, varying in width from 200 to 700 feet, and with sufficient depth for navigation for at least 6 months in the year if the river was cleared of obstructions.

The natural obstructions to navigation are snags, logs, leaning timber, &c., and the cost of removing same, in order to make a navigable

channel in the river from the mouth to Gray's Ferry, is estimated by Mr. Harrison at $30,316.

This estimate includes the work of excavating across some 16 bends, to a depth of 5 feet and width of 30, with the idea that the current will possibly excavate a channel sufficiently large for the passage of boats when there is sufficient water in the river for them to run. While frequently on nearly all the small rivers passages are cut through timber, from one bend to another, and used as high-water chutes for boats, the excavating is a much more serious matter, and a device of doubtful utility. It would be better to adhere to the natural channel, if possible, and clear the same of obstructions.

On the Cache, Mr. Harrison reports that there are 28 of these short bends, where it is even impossible for the smallest boat to turn without frequent stoppages.

The Memphis and Little Rock Railroad crosses the Cache at a point 45 miles above its mouth. The bridge here has no draw, and as now built it is a serious obstacle to communication between the upper and lower sections of the river. Small boats run above the bridge, bringing all the freight to that point, from whence it is shipped east and west. The railroad, therefore, may be said to be the only outlet now for the commerce of the Upper Cache country. If it be desired to render navigation continuous, so as boats can navigate the whole length of the river without hinderance, some means must be taken to cause the railroad company to put a draw in their bridge sufficiently wide for the passage of the class of boats that would navigate the stream were it improved.

The commerce of the Cache country was in former times quite extensive. The shipments of cotton amounted to 40,000 bales annually, but a variety of causes have led to its decline, so that now it amounts to only about one-third of the above amount.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. ZEPH. HARRISON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 16, 1880.

MAJOR: I have the honor to present herewith my report on the recent examination of Cache River, Arkansas.

The headwaters of this river are in Green County, in the northeastern corner of the State, from whence it flows in a southwesterly course, dividing this county from that of Randolph and Lawrence, and crossing the counties of Craighead, Jackson, and Woodruff, and empties into White River 1 mile above Clarendon. The length of the river is 600 miles, 250 of which were included in my examination.

* * * * * * *

I transported our effects by wagon to Cache River, 12 miles distant, at a point called "Martin's," and made this the initial point of my reconnaissance, as the river above is incapable of improvement without great expense, and no commerce to warrant it.

We then descended the stream, taking its sinuosities, soundings, number of snags, &c. The stage of water was about 6 feet above extreme low-water, and on the rise. The banks were very low, being often concealed by the high-water, and nearly the whole country was flooded. The rain was heavy and incessant.

This part of the river was very tortuous, the bends being short and very numerous,

and no stretches of water could be seen longer than 100 yards. It is very similar to a swamp, and the prevailing timber being cypress, the high stumps project out of the water and hold the drift; consequently, this is a long and almost continuous jam for nearly 50 miles, broken, however, by broad and expansive lakes, which have an uniform depth of 5 feet at low-water.

We made very slow progress over this stretch, as we could not unload the boat, but were compelled to clear a channel through the high-water. Below this stretch, and down to Gray's Bridge, we found these lakes to be quite numerous, but the river has no continuous channel, swift currents running as before, through the cypress timber, being the only connection.

Below this bridge, however, down to the mouth of the river, there is a continuous channel, with sufficient water for navigation 6 months in the year, if the river be cleared of its obstructions.

This part of the river varies in width, being from 250 to 700 feet wide, generally 350, and has an average depth of 12 feet at low-water. The bottom is sand or gravel. The banks are high, steep, non-caving, and composed of soil overlaying clay. The farms are more numerous on this part of the river.

CHARACTER OF ADJACENT COUNTRY.

This valley of the Cache is one of unsurpassed fertility. Some of the finest cotton-belts in the State are on this river. Luxuriant cane, the index of good cotton land, here grows in profusion. Corn, wheat, and the other cereals are grown sufficient for home consumption. For the sake of description the lands may be divided into three classes, viz, the first and second bottom lands and the high lands.

The first bottom lands, together with the swamps and marshes, are covered with a very superior growth of timber. Cypress is found in abundance and generally large. Pupelo gum is the prevailing wood, however; it has a shape peculiar to itself, having a diameter at low-water mark of 10 feet very often, and of, at most, 2 feet at high-water; above this it assumes the ordinary dimensions of the black gum. It is the lightest as well as the finest timber in this section of country.

Oak is also found here, but the finer varieties, embracing the post, overcup, red, and white, are found in the second bottoms, the last mentioned in unlimited quantities. There are also in the second bottom lands gum, elm, maple, sassafras, birch, beach, willow, pawpaw, pecan, iron-wood, and other growth indigenous to that climate.

This class of land is about the elevation of high-water, and is not subject to many overflows, but as yet is all timbered.

The cultivated class, or the high lands, lay very high, being from 30 to 50 feet above low-water. There is a ridge of land in this class, on the east side of the river, called Jones's Hill, extending from De View down to York's Landing, 26 miles long, and a mile or more wide, which is almost one vast cotton-field, and raises over a bale to the acre in good seasons. This cotton is said to rank among the highest grades.

TRIBUTARIES.

Bayous Cache, Calatchie, and De View are the only tributaries of the lower river; each is 120 feet wide at the mouth, and distant 120, 65, and 35 miles respectively from the mouth of the river.

Bayou Cache is an outlet from White River into Cache River, although in times of high-water on the latter stream the current is the other way.

The banks on these bayous are similar to those on the main stream, but the timber is not so thick, dense cane-brakes lining the banks on either side. The water is deep and the current sluggish. Three large steam-gins are located on the Bayou Cache, but on account of the drift in the bayou the cotton is hauled to Des Arc, on the White River. Several large lakes and swamps have their drainage into the river. Considerable timber is taken from these every season.

OBSTRUCTIONS TO NAVIGATION—IMPROVEMENTS AND ESTIMATES.

The obstructions to navigation in Cache River consist of snags, embedded logs, drift piles, sand-bars, and leaning trees. From Gray's Bridge to the mouth of the river, a distance of 160 miles, by pilot's estimate, I counted 2,655 snags, 76 drift piles, and 3,800 leaning trees about to fall in the stream, but on account of high-water the number of snags will have to be considerably increased.

Having been informed of certain localities where the shoalest water could be found, I took some pains in thoroughly sounding them. Two of these are sand-bars about 30 and 35 miles respectively from the mouth of the river. These bars reach across the river, widening the channel and reducing its depth to less than 1 foot of water in the dry season.

For these places I would suggest the building of ordinary wing-dams, sufficient to scour out a channel, say, 30 inches deep at low stages.

I estimate the cost of these at $3,000.

The rest of the points referred to are masses of sunken logs, embedded in sand and gravel.

The removal of these is all that is necessary.

I also counted 28 short bends, where it is impossible for the smallest boats to turn without stopping.

There are 16 of these in which the point is so narrow that cut-offs can be made advantageously and with little expense. The timber can be cleared to a width of 50 feet, and the earth excavated to a depth of 5 feet and width of 30 feet. I have estimated this excavation to be 16,000 cubic yards.

There is a great deal of dangerous timber along the banks, which might be cleared and chopped into 20-foot lengths to a width of 20 feet on either side, and the trees girdled as much farther back from the river.

The length of this clearing is about 120 miles, and will take about 8 months' work for 30 men. This would cost about $110 per mile.

The Memphis and Little Rock Railroad has a bridge across the river 40 miles from its mouth, which consists of 18-foot spans on piling driven into the river-bed. This is the most serious obstacle to navigation, and should be changed to accommodate a draw.

For pulling snags, removing drift, and raising sunken logs a small steamer could be chartered and fitted with the necessary crane, shears, &c. The shortness of the working season during low-water would scarcely warrant the building of a new boat. The monthly expenditure of running this boat would be—

Charter of boat, with ordinary crew, say	$650
Supervising engineer	150
Mate	75
Cook and helper	60
10 extra men, at $40	400
Subsistence for 17 men, at 50c. per day	255
Fuel for boat	50
Total	1,640

ESTIMATE OF COST OF PROPOSED IMPROVEMENT OF CACHE RIVER, FROM GRAY'S BRIDGE TO ITS MOUTH, 160 MILES.

Removing snags, drift, and sunken logs, 3 months' work; and 1 month for moving, 4 months, at $1,640	$6,560
2 wing-dams, at $1,500	3,000
Excavation, 16,000 cubic yards, at 30 cents	4,800
Clearing the banks 40 feet wide, and girdling the same width, $110 per mile, 120 miles	13,200
Contingencies, 10 per cent	2,756
Total	30,316

By the expenditure of this sum the safe navigation of the river can be secured for at least 6 months in the year.

COMMERCIAL STATISTICS.

The amount of commerce carried on in past years on Cache River was quite extensive, engaging constantly during the season 1 large and 2 small steamers. At Mayberry's Landing was located for many years a warehouse for cotton, 40 feet wide and 160 feet long, which has since been burned. But a variety of causes have of late years been brought to bear on its commerce, until now it has sunk to one-third of its past proportions.

The steamer Trader runs from Gray's Bridge to the railroad bridge. This bridge broke the connection between the upper and lower river, and left the people at the mercy of a non-competitive road. To show the railroad discrimination against this section of country, the tariff of a bale of cotton from Little Rock to Memphis, 135 miles, is $1, while from Surrounded Hill, on Cache River, to Memphis, 83 miles, it is $1.50.

The river has been filling up with so much drift of late that it takes four times as long now to make a trip as it did formerly. Private individuals have done considerable work on the river, pulling the worst snags and cutting the more dangerous timber, but they have since become discouraged, and many prefer the long haul over the swamps to Des Arc to the uncertainties of the river.

The roads over these swamps are nearly impassable in the wet season, and it is often late in the spring following before they get their crops marketed at all. Notwithstanding all these difficulties, about 15,000 bales of cotton, 5,000 tons of seed, 12,000,000 feet of lumber, and some grain, furs, cattle, and poultry were taken by river from the valley of the Cache during the past season. It is computed that the trade diverted from the river of late years amounts to 40,000 bales of cotton. No trade is carried on below the railroad excepting rafting.

The following is a list of the principal steamboat landings and bales of cotton shipped from each:

Landings.	Distance from mouth.		Bales of cotton.	Tons of seed.	On which bank.	Remarks.
	By water.	On air line.				
Memphis and Little Rock R. R.	45	15	.....	.....	Right.	Warehouse 100 by 50 feet.
Surrounded Hill	50	17	1,000	350	...do ..	
Sandy Bank.....	55	20	100	40	...do ..	
York's	87	31	500	200	Left ..	
Hammond's	95	34	3,000	1,000	.. do ..	
Mayberry's	110	38	3,000	1,000	.. do ..	Warehouse 50 by 50 feet.
Bayou Cache.....	119	40	1,000	300	Right	
Gage's Point.....	125	43	3,000	1,000	Left ..	Warehouse 40 by 50 feet.
De View	140	50	1,200	400	...do ..	
Augusta	160	58	800	250	Right.	Gray's Bridge.

Very respectfully submitted.

ZEPH. HARRISON,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

P 35.

EXAMINATION OF SAINT FRANCIS RIVER, MISSOURI AND ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 10, 1881.

GENERAL: I have the honor to submit herewith a report upon an examination of the Saint Francis River, Missouri and Arkansas, made under my direction under the provisions of act of Congress approved June 14, 1880.

The law provided for two examinations of the river, as follows:

Saint Francis River from Greenville, Missouri, and Saint Francis River, from Greenville, Missouri, to the Cairo, Arkansas and Texas Railroad.

As the former necessarily included the latter, the examination was made continuous from Greenville, Mo., to Lester Landing, Ark. (to which point the improvement of the Lower Saint Francis has been carried under former appropriations), and the results are embodied in one report.

The field party was in charge of Mr. J. B. Rohrer, assistant engineer, and his report, which will be found annexed, gives a sufficiently clear idea of the character of the stream, the obstructions to navigation, and the difficulties to be overcome in attempting to make the river navigable through the whole length examined.

From Greenville to the Cairo, Arkansas and Texas Railroad, a distance of 66 miles, the obstructions to navigation are shoals, snags, logs, bowlders, and drift-piles, the latter in places extending more than half

way across the stream. The estimated cost of improving this stretch of the river is $24,426, and then only boats of the smallest class would probably navigate the river.

At the railroad crossing the bridge is without a draw-span, consequently all communication for steamboats is cut off between the upper and lower sections of the river.

From the railroad to Lester Landing, in addition to the obstructions in the shape of snags, logs, and leaning timber, the river is at points completely blockaded by accumulations of drift, forming obstructions somewhat similar, though less in extent, to those that formerly existed in the raft region on Upper Red River, Louisiana. In the Sunk Land region, the channel of the river is at times completely lost in the timber and undergrowth. To improve this stretch of river, we should have to resort to dredging in addition to the removal of the above obstructions. No estimate for this is presented, as a much more detailed and extended examination would have to be made, so as to select the best route through the lake. Sufficient information has been gained, however, to justify the statement that the cost of improvement will greatly overbalance any perspective advantage to be gained. The estimated cost of removing the first raft below the railroad crossing is placed at not less than $20,000.

An examination of the river from Greenville, Mo., down was made under the direction of Colonel Simpson in 1873, the report upon which will be found in the Report of the Chief of Engineers for that year, page 476. Colonel Simpson recommended that, as the commerce of the country would not justify the expenditure of so large a sum as would be required to make the river navigable, no appropriation be made. In this I concur.

No reliable statistics of the commerce could be gained, but it is comparatively small. The upper section of the river runs almost parallel to the Saint Louis and Iron Mountain Railroad, and at a distance from it of about 10 miles. The railroad at present transacts all the business of that section of the country.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. J. B. ROHRER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 10, 1881.

MAJOR: I have the honor to submit the following report of the examination of the Saint Francis River from Greenville, Mo., to Lester Landing, Ark.

In accordance with the instructions received on November 23, 1880, I proceeded to Greenville, and, after procuring my outfit, commenced the examination.

My estimate of the length of river from Greenville to the Cairo, Arkansas and Texas Railroad is 66 miles, and from the railroad to Lester Landing 164 miles, making the total length of river examined 230 miles.

Greenville, the county seat of Wayne County, Missouri, is situated 15 miles east of the Iron Mountain Railroad on a flat area of ground on the left bank of the river; has two stores and about 125 inhabitants.

The surrounding country is hilly, on which there is very fine pine timber. Other varieties of timber, as oak, hickory, ash, walnut, sugar tree, maple, gum, and hackberry, are in the region and along the river.

The stage of the water at the beginning of the work was about 1½ feet above low-water, with an oscillation at that point of 25 feet.

From Greenville to Cutler's Mill, a distance of 6 miles, the river is from 75 to 200 feet wide; has 1 mile of leaning trees, about fifty snags, and seven shoals, the latter varying in depth at low-water from 6 inches to 2 feet. The worst of these shoals can be greatly improved by confining the water to one channel instead of having two or more chutes, as at present. The chutes can be closed by stone dams, the material for which can be obtained in the immediate vicinity.

The banks in this reach of river vary in height from 6 to 25 feet, except about 1 mile below the town, where the river flows at the foot of rocky bluffs which are about 200 feet high.

Near Cutler's Mill there is a spring which has a regular flow, and of such a capacity that in the low-water season it is a prominent feeder to the river.

From Cutler's Mill to Stanley's Shoals, a distance of 14 miles, there are sixteen shoals, varying in depth at low-water from 6 inches to 2½ feet. A number of these shoals can be improved by concentrating the water to one channel by low-water dams. Other shoals are caused by logs and bowlders, which catch the sand and gravel that may be moving on the bottom of the river. The shoals created by the latter method are generally very short. This reach of river varies in width from 75 to 250 feet, has about 5 miles of leaning trees, and contains one hundred snags.

From Stanley's Shoals to Indian Ford, a distance of 21 miles, there are about 6 miles of leaning and overhanging trees, eleven shoals, and one hundred snags.

There are miles in this reach of river on which very little work need be done, being generally of a good width and depth and free from dangerous snags.

From Greenville to Indian Ford the river very often flows along the bluffs, but at the ford it leaves the hills and passes through the low land, having banks from 10 to 20 feet high.

About 9 miles above Indian Ford the Mingo River, a stream about 75 feet wide, enters the Saint Francis. Smaller streams also furnish water to the river.

From Indian Ford to the Cairo, Arkansas and Texas Railroad, a distance of 25 miles, I found a few miles of leaning trees, one hundred and twenty snags, and several drift-piles, the latter extending half way across the river.

About 1½ miles below the railroad is a drift-pile about 200 feet in length, completely obstructing the river. It is composed of logs, trees, and the offal of the saw-mill at the railroad bridge.

The "Big Raft," the next obstruction in the river, is about 25 miles below the railroad. By the time I arrived at the raft the river had risen to within 3 feet of high-water, and about 12 feet above low-water. At this stage of the water I was unable to examine more of the raft than the top, which is higher than the banks and is overgrown with tall weeds.

A description of the raft is found in the Report of the Chief of Engineers for 1873, page 477, in the report of Mr. McKown on his examination of the Saint Francis River. The part pertaining to the raft is as follows:

"At this place the river is choked with a great quantity of drift, which is piled up 12 or 15 feet high, composed of logs, trees, timber, and all the *débris* that would naturally find its way into the stream during high-water. The raft is in two principal parts: the upper is about 800 feet long, 300 feet wide, and 12 feet deep; then an interval occurs of about 1,800 feet, which contains some drift, and is full of snags; then we come to the lower portion, which is about 1,000 feet long, 300 wide, and 15 deep."

The positions of the different portions of the raft are the same now as when examined by Mr. McKown, and the indications are such as to justify me in accepting his general dimensions. The raft has undoubtedly grown at the upper end, but portions of the lower end have broken away and lodged farther down the stream.

Leaving the raft and proceeding onward, we find, for the next 20 miles, the banks to be from 2 to 10 feet high, the river very crooked, and from 200 to 300 feet wide, although in many places half the width of the stream is grown up with willows. In this reach of river there are six drift-piles, one of which extends across the channel; these drifts vary from 5 to 50 feet in length. Four trees have fallen into the stream, obstructing the channel and affording fine opportunities for forming larger obstructions.

There are seventy-five snags, about 5 miles of leaning and overhanging trees, and in two places large trees stand in the channel. Many logs and snags are undoubtedly covered at this high stage of water. In this reach there are several shoals, which are about 2 feet deep in low-water. The material on the bottom of the river is sand.

In the next 20 miles we have generally a very crooked stream, although there are a few stretches of fine river. The width ranges from 200 to 300 feet, except in one place, where it divides into two chutes, 75 and 150 feet, respectively. The larger of these chutes is blockaded by a drift-pile, whose length is 200 feet. Four other drift-piles close about half the width of the river, and in several instances are on the channel side of the stream in the bends.

There are sixty snags and about 10 miles of leaning and overhanging trees, the

latter being exceedingly bad on the bends. The banks vary from 2 to 6 feet high, those under 4 feet being covered in very high water.

From the lower end of the preceding reach to Chalk Bluff, a distance of 15 miles, the river is very crooked, more especially on the latter part of the reach, where the stream is formed by a succession of bends—some being very sharp.

The river is from 250 to 300 feet wide, its banks varying from 4 to 15 feet, except in a few places, where the bottom lands are covered with water. It is obstructed by nine drift-piles, two of which extend across the stream, their respective lengths being 10 and 100 feet. About 5 miles of leaning and overhanging trees, together with seventy-five snags, would interfere with navigation.

Chalk Bluff is a small town situated amongst the hills on the right bank of the river. The river leaves the hills shortly after passing the village.

From Chalk Bluff to Brown's Ferry, a distance of 17 miles, the river is from 200 to 300 feet wide, has seventy snags, about 6 miles of leaning trees, and seven drift-piles. Two drift-piles extend across the river, one of which is 200 feet long. Many of these drift-piles have weeds growing on them, resembling, in this respect, the "Big Raft."

Some of the bottom lands are covered with water, the latter being 1½ feet below high-water.

About 1 mile below Chalk Bluff there is an old mill-race, whose width and length are about 50 feet and one-fourth of a mile, respectively, through which there is a strong current. About 2½ miles of river, almost devoid of current, intervenes between the entrance and outlet of the mill-race.

At Brown's Ferry the river divides into two chutes, each 150 feet wide, which form Seven-Mile Island.

Near the head of the right chute is an accumulation of logs, trees, and *debris* in general, which obstruct the channel. The left chute is somewhat better, although it has a great number of fallen trees, logs, is nearly grown up in many places with willows, has about twenty-five snags, and near the foot of the island is closed by a drift 200 feet long. Where the waters come together again they form a clean river, 300 feet wide and 3 miles in length. From this point to the head of Ten-Mile Island, a distance of 3 miles, we have two drift-piles that completely obtruct the river, being, respectively, 50 and 200 feet long.

For about half a mile of this reach, thirty snags, growing trees and brush, fallen trees and tree-tops, mingled with logs, form such a continuous mass as to make navigation by skiff very difficult.

On the lower end of the reach the water is over the banks, being a few inches deep in the bottoms. A 2-foot levee has been built on the Missouri side of the river by the authorities of Dunklin County; but it is of little value, as it is broken in many places.

Ten-Mile Island is formed by the river dividing into two streams, and are known as the Saint Francis River and Varner's River. The former is closed by drift and vegetation, the latter being the navigable channel.

The head of Ten-Mile Island is the beginning of the "Sunk Lands."

The entrance to Varner's River is about 50 feet wide, and for the first mile is very crooked, and has tupelo gum trees growing in the channel. Logs crossing the stream about every 300 feet and leaning trees skirting the water-way are the greatest additional obstructions to be found in this distance.

On Ten-Mile Island and on the mainland there are some good farms, the cultivated land on either side of the river being from 2 to 5 feet above the water. The water at this stage was 6 inches below high-water and about 1 foot above low-water, making the oscillation 1½ feet. This small oscillation is caused by the water spreading over a large area of land. On the east side of Ten-Mile Island, the situation of Varner's River, the width of the water is about 1 mile, and is grown up with timber, principally tupelo gums.

The Varner's River channel was cleaned some years ago by a man by the name of Suggs, under a contract with the authorities of Dunklin County, Missouri. This channel for the next 10 miles is exceedingly crooked and varies in width from 25 to 100 fe pt near the lower end of the reach, where it passes through a series of lakes, tor, more properly speaking, areas devoid of timber. In this reach there are about wenty trees, an equal number of snags, and numerous cypress knees obstructing the channel.

The depths in this 10 miles of river are as follows: For ½ mile the depth is 2 feet; for 4½ miles, 3 to 4 feet; and for 5 miles, 5 to 6 feet. In many places in this reach the bottom is covered with vegetation.

For the next 3 miles the channel is generally defined by timber, is from 100 to 200 feet wide, and from 7 to 9 feet deep. Aquatic plants then make their appearance in abundance. Flag defines the channel, which varies in width from 50 to 200 feet, and is skirted with smart-weed, which increases in quantity as we move down the stream, gradually narrowing the channel and finally closing it. The smart-weed is about 7 feet long, and extends above the surface of the water, being, in the thick growth, a formidable obstruction. The distance through the worst growth is about 1 mile.

For the next 3 miles the channel winds amongst the trees and vegetation, giving varying widths, from almost no channel to fine stretches of river.

Two miles farther on we have good river, but in the following 6 miles the channel, in some places, is narrowed up by smart-weed, and for the greater distance is lost in tupelo gum timber, there being no defined channel. At the end of this reach the waters again come together; but this feature is not noticeable, as the Saint Francis River is choked with vegetation.

In the next 12 miles, which brings us to Bolin's Ferry, the channel is from 2½ to 7 feet and sometimes over 10 feet deep, and winds through the vegetation, with widths varying from 25 to 500 feet, except in a few places, where it is entirely closed.

In traveling over the last two reaches an occasional island is seen, otherwise there is no land in sight, the river being some miles in width.

At Bolin's Ferry the water is about 1½ feet below high-water, and has an oscillation of about 3½ feet.

The channel for the next 11 miles is open, varying in width for part of the distance from 25 to 150 feet, depth from 3½ to 6 feet, and for about 2 miles the channel is almost straight, about 500 feet wide, and over 10 feet deep. This fine stretch of river crosses the most southerly boundary of Missouri.

The channel of the succeeding 5 miles is about 150 feet wide, 5 feet deep, and is well defined by flag.

Three miles more brings us to Lester Landing, Arkansas. This last reach of river passes through a cypress brake, and has an average depth of 4 feet. The steamer Marianna occasionally makes trips through the unimproved channel as far as the Missouri line, the owner of the boat having a plantation in that vicinity. Some of the land on the islands in the upper part of the "Sunk Lands" are cultivated, but the only product now shipped to market is cotton. Nearly all of this staple is brought to market by way of Malden, thence by rail to New Madrid, on the Mississippi River.

From the Cairo, Arkansas and Texas Railroad to the "Sunk Lands" there are farms scattered along the river, the most densely populated settlement being from Chalk Bluff to Brown's Ferry.

Cotton, the principal product of the soil, which produces three-fourths of a bale to the acre, is shipped to market by way of the narrow-gauge railroad running from Malden to New Madrid. The distance from Brown's Ferry to Malden is 15 miles. Quite a great deal of cotton is raised, each farmer having from 5 to 15 acres in cultivation. Although large quantities of the staple are produced, yet I deem it insufficient to warrant the expenditure of the great amount of money necessary, either to cut and dredge a channel through portions of the "Sunk Lands" to river communication below, or to remove the "Big Raft" and the other numerous and formidable obstructions in the river from the "Sunk Lands" to the Cairo, Arkansas and Texas Railroad.

The river from Greenville to the Cairo, Arkansas and Texas Railroad has five recognized ferries, which are in good condition, and apparently do considerable business. Quite a number of farms are on the banks of the river. Corn, oats, and wheat are the products, which at present are of little value otherwise than for home consumption.

If cheap transportation is afforded the country along this part of the Saint Francis River, it will be able to put its fine timber, cereals, stock, and baled hay in the market.

In the vicinity of Indian Ford there is considerable iron ore, reputed to be of a very good quality, which would also find its way to the market. Reliable statistics could not be obtained, so have been compelled to give the general indications.

A small steamboat, which intends carrying lumber and the products of the country to the railroad, has just been completed at Cutler's Mill.

Should it be deemed advisable to improve the reach of river from Greenville to the Cairo, Arkansas and Texas Railroad, I have no doubt but that that country would be greatly benefited by increased population, and the country at large by the resources of the region. I therefore append an estimate of the cost of improvement for this part of the Saint Francis River for low-water navigation.

ESTIMATE.

Building low-water dams, 3,000 cubic yards, at $3		$9,000 00
Flat-boat, with necessary tools		3,000 00
Expenses of boat for one month, as follows:		
Engineer in charge	$150 00	
Mate	75 00	
Cook	60 00	
Fifteen men, at $40 per month	600 00	
Subsistence, 18 men, at $15 per month	270 00	
Total	1,155 00	

Removing snags, &c., 8 months, at $1,155	$9,240 00
Contingencies, 15 per cent	3,186 00
Total cost of improvement from Greenville, Mo., to Cairo, Arkansas and Texas Railroad	24,426 00

This improvement should be made during the summer and fall months, when the stage of the water is low.

Very respectfully,

J. B. ROHRER,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
United States Engineers.

P 36.

EXAMINATION OF OBION RIVER, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1880.

GENERAL: I have the honor to submit herewith a report upon the examination of Obion River, Tennessee, in accordance with act of Congress approved June 14, 1880.

The river is formed by the junction of the North, South, Rutherford, Harris, and Big Davidson forks, near the northwestern part of the State. It flows through Obion and Dyer counties, and empties into the Mississippi River at Hall's Point. Four miles above its mouth it receives the waters of the Forked Deer and tributaries.

The examination was made by Mr. Zeph. Harrison, assistant engineer, and extended from Crockett, the point of crossing of the Mobile and Ohio Railroad, to the junction with the Mississippi River, a distance estimated at 190 miles.

The upper section of the stream is crossed by the following railroads, viz: New Orleans, Saint Louis and Chicago Railroad, Nashville and Chattanooga, Mobile and Ohio, and Memphis and Paducah, which do all the freight business for the section of country through which they pass. All of the bridge crossings of the stream are built upon pile foundations, and, being without draw spans, cut off all water communication between the upper and lower portions of the river. The lower of the bridges, that of the Paducah road, is 115 miles from the mouth, and it is only necessary to consider this lower section of the river in the contemplated improvement.

Mr. Harrison states that the examination showed that although the river is somewhat narrow, its banks are high and non-caving for the greater part of its length, and that there is a good channel throughout the whole length of the river, the least depth in the lowest stage being 4 feet, except on the shoals occasioned by imbedded logs, the removal of which would cause the shoals to disappear.

The obstructions to navigation are snags, logs, leaning timber, &c., the removal of which would constitute the principal work to be carried on in order to make the river navigable for the class of boats that navigate the stream. These boats are of the same character as those on the Forked Deer, the narrowness of the river and the shortness of many of the bends not allowing any but boats of small dimensions to run on the river except in the lower part.

Mr. Harrison's estimate for removing the obstructions as above-mentioned is $28,809.

The Obion runs through a fine and heavily timbered country, and the principal article of export is lumber, of which vast quantities are annually shipped both in the log and as sawed lumber. Numerous saw-mills line the stream, and they are kept in constant operation. The estimated value of the production is given by Mr. Harrison as upwards of $2,800,000. The railroads control all the trade of the upper section of the river above Obion Station, the crossing of the Paducah Railroad; below this point the only outlet to the commerce is by steamboat.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. ZEPH. HARRISON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn.

MAJOR: Having received your instructions of October 8, 1880, to make an examination of the Obion River, Tennessee, with a view to its improvement, I respectfully make the following report:

I left Memphis with one man, a large skiff, and a complete camp outfit. We reached Crockett, on the Mobile and Ohio Railroad, the next day. Near this place, which is in the northwestern corner of this State, the Obion River is formed by the junction of the North, South, Rutherford, Harris, and Big Davidson forks. It has a southwesterly flow through Obion and Dyer counties and empties into old channel of the Mississippi River, 4 miles by water from the main river; this stretch has since received the name of Obion also, as no water flows through it from the Mississippi excepting in high stages. The length of the river is 225 miles, pilots' measurement.

Having heard at the outstart of the numerous obstructions in the river, I engaged two more men and started my examination at the crossing of the Mobile and Ohio Railroad, as there are only 10 miles of deep water above, and the railroad takes all the freight from that section. The river was very low, not over 1 foot above extreme low-water. We found considerable drift, and in many places were compelled to drag the boat around, sometimes over banks 5 feet high. The upper river has a width of about 150 feet, surface of water; the banks are from 5 to 15 feet high and 180 feet apart. The least depth of water is just below Kimberlin's Mill, 180 miles from the montq, being 18 inches; the greatest depth is 60 feet and 85 miles from the mouth, while the average is about 7 feet at lowest stages. Midway between the last-mentioned points and near Obion Station, on the Memphis and Paducah Railroad, the river divides into six different cut-offs, the largest of which is nearly as wide as the river, which is very narrow here and completely filled with drift. It has the appearance of an immense wood-pile 30 feet high and 1,500 feet long. This whole region, embracing nearly 2 miles of river distance, is one set of rafts, but advantage can be taken of a certain cut-off, which is nearly free from drift and will shorten the distance by water considerably. This cut-off has an average breadth of 60 feet, a minimum depth of 3 feet, and is about a quarter of a mile long. It began raining very hard while we were at this place, and the river commenced rising, but we kept ahead of the main rise until we reached the mouth. The numerous booms at the different saw-mills along the banks gave us considerable trouble as well as the rafts of saw-logs we encountered, which often detain the steamers for hours at a time.

CHARACTER OF ADJACENT COUNTRY.

The valley of the Obion River varies in width from 4 to 10 miles. That part which is subject to frequent overflows is very poor and unproductive, but there is not much land of this class, as shown by the high banks. The rest is extremely rich, and is spoken of very highly. "Killebrew's Resources" and "Safford's Geology of Tennessee" place this section among the very first in the State, both as to cotton-production and timber. Some 3 or 4 miles from the river there is a kind of soil especially adapted to the growth of tobacco. This article is raised in large quantities, and has a nam for its fineness and silkiness. There seems to be a variety of soils along the Obion River, each of which is a favorite with the farmer for the culture of some especial

article. Drought never affects this country as it does the majority of places; this is probably owing to the immense forests, which are unequalled in this or any of the neighboring States. The undergrowth is principally cane and paw-paw, while the larger timber consists of poplar, oak, gum, walnut, beech, sugar-tree, and hickory. Some of these trees are of enormous size and height, fairly rivaling the mammoth trees of California.

At the exposition held in Nashville in 1872 was exhibited a cut 12 inches long taken from a sassafras tree grown on this river which measured inside the bark, which was 2 inches thick, 4 feet and 8 inches in diameter. This cut, taken from the tree at a distance of 12 feet from the ground, was perfectly solid. Here also are found mammoth poplar, and even oak, trees reaching the enormous height of 150 feet and measuring 5 and 8 feet in diameter. But independent of these extraordinary trees, the timber of the country is wonderfully large and stands exceedingly thick upon the ground. Numerous saw-mills line the river bank and are constantly running. Nearly all the capital engaged in this business is from Cincinnati or Chicago, and I heard of not less than twenty mills in prospectus. Fine herds of cattle of the improved kinds of stock graze among the cane, which appears wherever the forests are not too thick to check its growth.

TRIBUTARIES.

Mill, Richland, Clover Lick, and Reed creeks and Reelfoot Bayou empty into the Obion River, the last mentioned being the outlet for the celebrated Reelfoot Lake. These creeks vary in width from 30 to 90 feet near the mouths, and generally have as good a channel up a few miles as the main river. The timber is similar to that last mentioned.

OBSTRUCTIONS TO NAVIGATION, IMPROVEMENTS, AND ESTIMATES.

The ordinary obstructions existing to a greater or less extent on all rivers are found on this stream, viz: snags, drift, embedded logs, overhanging timber, &c. Very few of the farms run down to the bank, consequently overhanging timber is one of the most serious obstacles, and runs nearly the whole length of the river. This timber, being very large, often falls across the entire width of the river and holds a considerable amount of drift above it. In a number of places logs have become embedded in the bottom, which, in the upper part of the river, is about a foot of sediment over clay. But in many respects the Obion is a very superior river. Although it is somewhat narrow, its banks are high and non-caving, and there is a deep channel for 235 consecutive miles, the least depth in the lowest stage being 4 feet, excepting the shoals occasioned by embedded logs. It is rather tortuous in places, but the steamers now running in the river have little trouble making the bends.

In the lower river sand appears, but the narrowness of the river keeps it from forming into bars. We counted 4,150 snags, 720 sawyers, 71 drift piles, 1 raft, 5,600 trees about to obstruct the river, and 21 places where there are embedded logs; but the number of snags and sawyers was probably small on account of the stage of water having risen from 2 to 3 feet above low-water. "Tigertail" is the name given to a canal dug by the State some years ago from Forked Deer into Obion River. From this canal to the mouth of the river, 4 miles, it is very narrow and one succession of drift and snags. It is from 6 to 10 feet deep and has a current of 5 miles an hour. It is the most important part of the river, however, as it is the outlet of the Forked Deer trade. Besides this there is very little work needed in Old Channel. The Memphis and Paducah Railroad has a bridge across the river at Obion Station. It is 24 feet above low-water in the clear and its spans are only 12 feet. This should be changed to a draw-bridge.

For the improvement of this river, a flat-boat could be built and arranged with shears to pull snags. The monthly expenditure of running this boat would be:

Supervising engineer	$150 00
Mate	75 00
Cook and helper	60 00
Ten laborers, at $30	300 00
Subsistence, 14 men, at $15	210 00
Total	79500

The banks could be cleared of timber to a width of 30 feet on either side; this I estimated at a cost of $112 a mile, and the distance to be 160 miles.

ESTIMATE OF COST OF PROPOSED IMPROVEMENT OF OBION RIVER FROM CROCKETT TO THE MOUTH, 225 MILES, SO AS TO MAKE IT NAVIGABLE FOR EIGHT MONTHS IN THE YEAR.

Flat-boat for removing snags, drift, &c	$2,000 00
Outfit of tools, rope, &c., $400; 25 per cent. for repairs, $100	500 00
Removing snags, drift, &c., five months' work, at $795; add one month for moving	4,770 00
Clearing the banks of timber, 60 feet wide, for a distance of 160 miles, at $112 per mile	17,920 00
Flat-boat for quarters, &c	1,000 00
Contingencies, 10 per cent	2,619 00
Total estimated cost of improvement	28,809 00

COMMERCIAL STATISTICS.

There are four steamers which ply in the lower river, viz, the Alph Stevens, Mark Twain, Obion, and Dyersburg, the total tonnage of which is nearly 2,000; six keel-boats also are engaged. These boats seldom ascend the river very high, on account of the snags, but manage very well in high stages of water, when they are able to go through the different cut-offs and escape the drift which is generally found in the old channels.

The principal article of export is lumber, of which vast quantities are annually shipped, both in the log and sawed.

The Memphis and Paducah Railroad is making an attempt at carrying the exports of the upper river country, but, being an unfinished road, it is unable to carry goods without an unreasonable tariff. The lumbermen were constantly complaining, while I was in that vicinity, of high rates and no cars. Where twelve cars a day were required for their business alone, only three would be furnished and sometimes none. Why the railroad authorities failed to see their own interests better than this, I could not see, unless their limited capacity could not keep pace with the requirements of trade. In addition, it might be said that the principal lumber comes from near the river bank, and the expense of hauling is another item which deducts from the profits of the business, consequently discouraging it to that extent.

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The value of the imports and exports in the valley of the Obion River amounts to $2,800,000.

Very respectfully submitted.

ZEPH. HARRISON,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

P 37.

EXAMINATION OF SOUTH FORKED DEER RIVER, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Memphis, December 16, 1880.

GENERAL: I have the honor to present the following report of an examination of the South Forked Deer River, Tennessee, made in accordance with act of Congress approved June 14, 1880:

The river heads in McNairy and Henderson counties, and, flowing in a general southwesterly direction, joins the main Forked Deer River about 8 miles below Dyersburg. It flows through Madison County, forms the boundary between Haywood and Lauderdale and Crockett and Dyer counties. It is the most important of all the branches that form the main stream. The examination was made by Mr. Zeph Harrison, assistant engineer, whose report is annexed, and extended from Jackson, Tenn., which was formerly the head of navigation, to its junction with the main Forked Deer.

The commerce of the country through which the stream passes is very considerable, as will be seen by reference to the statistics in Mr. Harrison's report. Before the introduction of the railroads all this commerce was carried upon the stream, and the crops had an outlet to the Mississippi River. Of late years, however, the Mobile and Ohio, the Mississippi Central, the Louisville and Nashville, and the narrow-gauge railroad from Brownsville, Tenn., northward, have been constructed, and the products have been diverted in other directions. All these railroads have bridges across the river, without draw-spans for the passage of boats, and consequently they act as complete obstructions to navigation. The Memphis and Paducah Railroad is now in course of construction, and will cross the river near Dyersburg. It is not known what character of bridge will be constructed, but judging from their bridges over other streams, it will be without a draw. If so built, it will block the river completely above that point.

As the railroad bridges are complete obstructions, as at present constructed, I do not deem it necessary to consider the upper section of the river above the Brownsville narrow-gauge road. From the latter point down the people are dependent upon the river for the transportation of their crops and the return of plantation and other supplies. The natural obstructions are snags, logs, and leaning timber, and their removal would constitute the principal improvement to be carried on to render the stream navigable at a time when there would be sufficient water in the river for navigation purposes. The total length of stream needing this work is about 100 miles, and the estimated cost of removing the obstructions is $19,250.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. ZEPH. HARRISON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 16, 1880.

MAJOR: I respectfully make the following report upon the recent examination of tha South Fork of the Forked Deer River, Tennessee, made under your direction:

The South Fork takes its rise in McNairy County, not far from Jackson (Madison County). It has a general southwesterly flow. It traverses the central part of Madison County, and then divides the counties of Haywood and Lauderdale from those of Crockett and Dyer, flowing into the Forked Deer 8 miles below Dyersburg. The length of the river is about 250 miles, 195 of which were examined; these distances were estimated by raftsmen on the river. Having understood that Jackson, on the Mobile and Ohio Railroad, was the old head of navigation, I made it the initial point of my examination. From this place I gradually descended the river in a skiff, with a party of three men, taking notes of the sinuosities of the stream, soundings, number and position of snags, accumulations of drift, &c. We were constantly troubled by foul weather, never having two fair days in succession. The drift also frequently compelled us to unload and carry the boat, with our effects, to a point below the obstruction. The stage of water varied at times from 4 to 6 feet above low-water.

CHARACTER OF ADJACENT COUNTRY.

The valley of the South Fork is very extensive, reaching eastwardly to within 10 miles of the Tennessee River. It varies in width from 1 to 8 miles. The "Mississippi Bluff" borders the entire valley on either side. The soils on this bluff are constitutionally different from those in the valley. The first is composed of a fine calcareous,

silicious earth, often presenting an ashen aspect as to color and consistence, but sometimes of a reddish cast, occasionally black, and sometimes orange; these are among the most fertile in the State. Tobacco, cotton, corn, wheat, oats, clover, and the grasses grow luxuriantly upon them, while the native growth is of marvelous exuberance. The second is the well-known "alluvial," more or less common in all creek and river valleys; this is good corn land, although it is generally in cotton. About two-thirds of the high lands and one-tenth of the bottoms are in a state of cultivation; the balance is covered with a dense growth of timber. White oak, ash, poplar, chestnut, and hickory predominate; but beech, elm, cypress, cottonwood, and other kinds are found here.

Along the escarpment of the bluff I noticed some very peculiar trenches about 10 feet wide, 5 feet deep, and running back perpendicular to the face of the bluff. I accounted for these by the supposition that they had been formed by the earthquakes of 1811–'12; they were probably very deep at the time, but have been filling in gradually and will eventually disappear. I also saw croppings of lignite near these places and one small mine.

TRIBUTARIES.

Little Middle Fork, Jones', Johnson's, Cub, Turkey, North Branch, Nixon's, and Otter creeks all flow into the South Fork They vary in width at the junctions from 30 to 100 feet and in depth from 5 to 10 feet. They are principally used for rafting. Turkey Creek has some fine chalybeate springs along its banks. The finest timber is found on these smaller streams. This is perhaps due to the main river overflowing. Cypress is the only exception, this confining itself to the swamps and overflowed land.

OBSTRUCTIONS TO NAVIGATION, IMPROVEMENTS, AND ESTIMATES.

The upper river is very sinuous, the bends being short and numerous. This part of the river is crossed by the Louisville and Nashville, the Mobile and Ohio, and the Mississippi Central railroads, which drain the country of its surplus products. Three more roads are being projected in the same vicinity, and it is thought will be built. The river here is also completely blocked up by drift in several places; therefore it does not seem advisable to improve this part. I have, however, estimated upon it. From Jackson to Sharon, 81 miles, the work of pulling the snags, removing a brush dam (mill site), and clearing the banks would cost at least $45,000. As the railroads here are able to do the whole business, and as there is competition enough already to reduce rates, I see no reason for any change. Below Sharon, however, the people are dependent on the river or a very long haul over bad roads. This part, from Sharon to the mouth, 114 miles, I have carefully estimated upon. The obstructions consist of snags, drift, and overhanging timber. I counted 3,850 snags, 122 drift-piles, and 7,600 trees about to fall in the water. For pulling the snags and removing the drift a small flat-boat can be built at Chestnut Bluff, where keel-boats are being constantly constructed. This boat should draw about 1 foot of water and have the necessary machinery and rigging for its purpose.

The best time for the work is from July to December, when the water is low.

The banks can be cleared to a width of 30 feet on either side. This would cost about $105 a mile.

ESTIMATE OF COST OF PROPOSED IMPROVEMENT OF SOUTH FORK FROM SHARON TO THE MOUTH, 114 MILES.

Flat-boat for pulling snags and removing drift, outfit, &c	$3,000
Five months in field	5,300
Clearing the banks 60 feet wide, felling the trees and cutting them into 12-foot lengths, 80 miles, at $105	8,400
Flat-boat for quarters	800
Contingencies, 10 per cent	1,750
Total	19,250

This amount judiciously expended would give safe navigation six months in the year.

COMMERCIAL STATISTICS.

Very little trade has been carried on of late years on the South Fork, for the reasons that the upper river country now has railroad facilities and the river is so full of drift that the larger steamers have refused to run in that trade any longer. Some rafting is still going on during high stages of water, but there is so much danger and expense

attending it that the annual decrease is very perceptible. From Chestnut Bluff a few hundred bales of cotton and some seed are taken by the steamer Obion at every rise in the river, but even this has fallen off so that the citizens of this place are building keel-boats, in the absence of steamers, as the only resort for marketing their goods. This mode of transportation in this kind of a stream is so expensive that it will eventually discourage exporting from that section, which embraces about 300 square miles outside of the district accessible to the railroads. As before mentioned, some years ago the head of navigation was at Jackson, which then had about 2,000 inhabitants.

* * * * * * *

Memphis is the market for this section, and draws from it considerable cotton and lumber. The people are talking of emigrating unless there be better communication with the neighboring districts, and cheaper as well as safer transport for their productions.

Very respectfully, your obedient servant,

ZEPH. HARRISON,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

P 38.

EXAMINATION OF NORTH FORKED DEER RIVER, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1880.

GENERAL: I have the honor to submit the following report of an examination of the North Forked Deer River, Tennessee, made in accordance with act of Congress approved June 14, 1880.

While the Forked Deer River proper is formed by the confluence of several streams, known as the South, Middle, and North Forks, the name of North Forked Deer has been given to the North Fork, and its continuation as the main river, after being joined by the other two branches, and as such has been included in the examination made from the initial point to the junction with the Obion, 4 miles from the Mississippi River.

The examination was made by Mr. Zeph. Harrison, assistant engineer, and party, and extended from Collins to the mouth, a distance of 140 miles. An examination of that portion of the stream below Dyersburg, a length of 34 miles, was made in 1873, under the direction of Major Suter, Corps of Engineers, the report upon which will be found in the Report of the Chief of Engineers for 1874, part 1, page 375. No appropriation was, however, made for the improvement.

The North Fork is formed by the junction of several smaller streams, near Trenton, a station on the Mobile and Ohio Railroad, in Gibson County. It flows in a general southwesterly course, forming the boundary between Dyer and Lauderdale counties, and joins the Obion River, about 4 miles above the junction of the latter with the Mississippi River. Its two principal branches are the Middle and South Forks. The latter river I am also required to report upon. The total length of the river is estimated at 250 miles, though it was only considered necessary to examine about 140 miles of it. This is divided into two parts, from Collins to junction with the South Fork, and from thence to the mouth.

In the first stretch, a distance of about 110 miles, the natural obstructions to navigation are snags, logs, and leaning trees. The river has a general width of about 100 feet, and though at various points it presents

a general depth of about 5 feet, there are many points where, during low-water, not over 1 foot depth is found. The river is very winding, rendering the navigation (even if clear of obstructions), except by steamers of the very smallest class, a matter of considerable difficulty.

Two railroads are now projected which will cross the upper section of the river. These are the narrow-gauge road from Brownsville, running northward, and the Memphis and Paducah Railroad. The latter has already constructed a bridge across the river at Dyersburg, under authority from the State, and, as built, will be a complete obstruction to navigation above that point, as no arrangement has been made for a draw. At the present time a portion of the north-approach span has been removed, to allow the passage of stave-boats. The gap now existing in the road will undoubtedly be closed up, and that section of the river above the bridge will be completely cut off from all communication with the section below. That part of the river from Dyersburg down, a distance of about 34 miles, will then be the only portion left in a navigable condition.

The lower section of the river, from junction of South Fork to the mouth, a distance of 24 miles, has a general width of about 150 feet, and a depth, at low-water, except on the bars, of about 3 feet. In the lower river the depth on the bars at low-water is less than 1 foot.

The obstructions to navigation, during either high or low water, are snags, logs, and leaning timber, and in low-water the bars and short bends. In this part of the river, as in the upper, only small steamers will be able to navigate, even if the improvement be undertaken.

Mr. Harrison estimates the cost of improving the river as follows:

From Collins to South Fork, 110 miles	$19,952 50
From South Fork, to mouth, 24 miles	15,415 75
Total	35,368 25

The products of the country through which the river passes consist of cotton, tobacco, corn, cattle, staves, lumber, &c., the estimated value of which is placed at about $2,000,000.

The report of Mr. Harrison, giving in detail the character of the country, obstructions to navigation, products, and estimate for cost of improvement, is appended.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. ZEPH. HARRISON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn.

MAJOR: I have the honor to submit the following report upon the recent examination of the North Forked Deer River, Tennessee, made under your direction:

This river is formed by the confluence of several streams near Trenton, on the Mobile and Ohio Railroad, and in the central part of Gibson County. Its general flow is westerly to Dyersburg, then southwesterly, dividing the counties of Dyer and Lauderdale; then westerly again, finally emptying into Obion River 4 miles above its mouth. Eight miles below Dyersburg the South Fork empties into the North Fork, and below this point it is sometimes called the main river, but generally known by the name of the North Forked Deer River to the mouth.

The mouth of the river was formerly at Ashport, on the Mississippi River, but a

great amount of drift having floated out of that river into the Obion and thence into the Forked Deer, the State made an appropriation for a canal between this river and the Obion. That part below this canal and down to Ashport is now called "Old" and "Lost" channels, and is never used, being completely blocked up with snags and drift. This canal is commonly called "Tigertail," and has diverted the entire trade from Ashport to Hale's Point, near the mouth of the Obion. The length of the river by the present channel is 250 miles, pilots' estimate.

The examination was conducted in an open skiff, with a party of three men, from the mouth of the river to "Collins'," 140 miles. Careful note was taken of the position and number of all snags, drift-piles, leaning timber, and bars. At the outstart the stage of water was about 1 foot above the dry-season level, and the weather favorable, but it soon changed to heavy rains and colder weather. The river rose 5 feet. This doubtless concealed many of the snags and other obstructions, but I had reliable information from the steamboatmen running on the river. The nature of the river, banks, and obstructions are different in the upper and lower river, consequently I will treat them separately.

COLLINS TO THE MOUTH OF SOUTH FORK.

(110 miles.)

This part of the river is very sinuous, the bends being very sharp and numerous. The river has a varying width of from 75 to 150 feet, averaging about 100. The depth was rather uniform, being generally 5 feet at low-water, but there are places where there is less than a foot of water in the summer. There are also holes occasionally as deep as 35 feet. The meanderings of the stream in the valley, which is from 1 to 3 miles in width, often brings it in contact with the bluffs, forming a bank of over 100 feet on one side and about 5 feet on the other. But the banks are generally 10 feet above low-water, and non-caving.

CHARACTER OF ADJACENT COUNTRY.

The escarpment of the plateau or highlands of West Tennessee, to which the general name of the "Mississippi Bluff" has been given, borders the river valley on either side. It is from 100 to 150 feet above the river. Two-thirds of the highlands are probably in a state of cultivation; the balance, together with nearly the whole of the bottom lands, is covered with a dense growth of timber. The soil of the highlands is what is known as "bluff loam," and is said to be the finest producing soil in the State. Cotton, tobacco, corn, and wheat are raised for export, as also cattle and hogs. All the cereals are raised sufficient for home consumption. The stock is of the improved kinds, and seldom need housing during the winter. Their range is among the canebrakes in the bottoms. Ash, hickory, black walnut, gum, poplar, chestnut, cypress, and the different varieties of the oak abound here. White-oak is found in unlimited quantities and of large size; paw-paw, hazelnut, and cane form the underbrush.

TRIBUTARIES.

Numerous small streams flow into the upper river, from either side, having their rise in the table-lands beyond. Escarpment, Bluff, and Tennessee creeks are the principal ones, having a width of 40 and depth of 8 feet near the main river. They are all lined with a wealth of dense timber, immense quantities of which are annually taken in rafts to Memphis.

OBSTRUCTIONS TO NAVIGATION, IMPROVEMENTS, AND ESTIMATES.

In the last few years some light work has been done by private enterprise in cutting the worst leaning trees, girdling others, and removing some of the more dangerous snags. The timber was cleared to a width of 100 feet on a narrow neck of land 1 mile below Dyersburg. It was hoped that, the timber being gone, a channel would eventually wash out for itself, but there are no indications as yet of its doing so. It is 550 feet across, and over a mile around; in this bend a boat is required to make five different stoppages before getting through.

Just above Dyersburg the Memphis and Paducah Railroad crosses the river. The north approach to the bridge was cut through last season to allow stave-boats to pass. Although this part of the road was finished, or nearly so, as I understand, it was never traveled, the termini of the gap being Trimble on the north and Covington on the south. This bridge, not being used, should be wholly removed, or changed to a draw. I counted on this part of the river, viz, from Collins to South Fork, 1,525

snags, 62 drift-piles, and 2,800 trees about to fall into the stream. The improvement would embrace the pulling of the snags, removing the drift, and clearing the banks. For removing the obstructions in the river a flat-boat can be built, with shears for pulling snags. There is every facility for building such a boat at Dyersburg, where the steamer Dyersburg, a screw-propeller, was built a few years ago. This boat can be operated with advantage for about five months during the low-water season, from June to December. The timber can be cleared from the banks to a width of 30 feet on either side, and 100 feet on the points in sharp bends; this I estimate at $115 a mile and for 70 miles.

ESTIMATE OF COST OF PROPOSED IMPROVEMENT OF THE NORTH FORK FROM COLLINS TO MOUTH OF SOUTH FORK.

Flat-boat with shears for pulling snags and removing drift, outfit, &c	$3,000 00
Five months in field	5,300 00
Clearing the banks, trees cut down and into lengths of 12 feet, 70 miles, at $115	8,050 00
Flat-boat for quarters	1,000 00
Contingencies, 15 per cent	2,602 50
Total	19,952 50

FROM SOUTH FORK TO MOUTH OF RIVER.

(Estimated distance, 24 miles.)

This stretch has a varying width of from 125 to 300 feet, generally about 150 feet, and a minimum depth of channel, excepting the bars, of 3 feet. The banks are very high, and, near the canal, constantly changing.

CHARACTER OF ADJACENT COUNTRY.

The above-mentioned bluff borders the river on the southeast; it is 180 feet above low-water in the highest places. On the highlands of this bluff the soil is nearly a foot thick, on a good clay foundation, and is very mellow and fertile. Corn and cotton grow well on this ground, but the best corn-lands are in the bottoms, which lay all along the right and part of the left bank; here the soil is a rich, dark, alluvial loam, from 10 to 20 feet deep, resting also on a clay subsoil. A large proportion of this section is still covered with forests of immense timber, which will not be cleared off for many years. There is a belt, however, toward the Mississippi, which is now in a state of cultivation.

Croppings of lignite, 4 and 5 feet thick, were seen in the bluffs. The timber is of the same kinds as that on the upper river, but much larger and finer. I saw numberless logs lying on the banks from 3 to 6 feet thick, and often 40 feet long. The white-oak timber here is especially adapted to the manufacture of staves, immense numbers of which are annually shipped in stave-boats to New Orleans. These boats hold from 40,000 to 60,000, and never return. There are no saw-mills on this part of the river, all the timber being shipped in the log.

TRIBUTARIES.

Mud Creek and Rick's Slough empty into the river from the north, and Oak and Chestnut creeks from the south; these are the only tributaries of any size, and are each about 50 feet wide at the mouth. They also have a good depth of water for rafting purposes, considerable timber being taken from them every year.

OBSTRUCTIONS TO NAVIGATION, ESTIMATES, AND IMPOVEMENTS.

The obstructions are principally snags, drift, leaning timber, and sand-bars. I counted seven hundred and twenty-one snags, five drift piles, and six sand-bars. These sand-bars are, perhaps, the worst obstacles in the river. The two largest ones are formed by deposits from the Mississippi backwater, and have made and washed away again each successive season for the last forty years. On account of these bars there has to be a rise of at least 3 feet before the smallest of the boats can ascend the river. Low wing-dams constructed of piling would confine the current enough to scour out a channel sufficiently deep to meet the ordinary wants of trade. I have estimated the total length of these dams to be 2,200 feet, and the cost to be $6,000. The boats heavily

loaded with cotton are often delayed for some time on these places. The following is a list of these bars:

Names.	Distance from mouth.	Length of bar.	Length of dam required.	River at low-water.	
				Width.	Depth.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Caney Point	1	200	600	150	0.5
Smith Chute	1¾	300	400	200	0.3
Rock Slough	2	300	400	175	0.4
White Oak Bar	4	200	500	300	0.1
Six Mile Cut-off	18	300	300	200	0.3

There are two large bends in the river—one near the mouth, and the other near South Fork. The former is called "Buggy's Cut-off," as the timber was cleared across the neck and some little earth removed by a man of that name. It is 700 feet across and over a mile around. The upper cut-off is only used in times of high-water. The timber is cleared here also to a width of 100 feet, but no excavation made. Here the old channel is over 3 miles, and the cut-off is 1,000 feet. The canal, mentioned above was not finished to a proper depth, under the supposition that a channel would wash out for itself; but, on the contrary, it has been depositing more than scouring. The only remedy is to confine the channel, as in the case of the bars, by a wing-dam. This I estimated at $2,000.

Near Key Corner there was the wreck of a large keel-boat full of lumber, extending two-thirds across the river. As we were returning I saw the steamer Beaver approaching this place, and I presume the *débris* is cleared away, but the boat is probably still there.

The improvement of this part of the river is similar to that of the upper river, with the addition of deepening the channel. The estimate for flat-boats need not be repeated, as the field can be extended to the lower river, but a third boat will be required on the work of the dams.

ESTIMATE OF COST OF PROPOSED IMPROVEMENT OF THE RIVER FROM SOUTH FORK TO OBION RIVER, 24 MILES.

Removing snags and drift, three months' work, at $1,060	$3,180 00
Wing-dams	8,000 00
Flat-boat for transferring material	500 00
Clearing the banks, trees cut down and into lengths of 20 feet, 15 miles, at $115	$1,725 00
Contingencies, 15 per cent	2,010 75
Total for this reach	15,415 75
Add the estimate for upper river	19,952 50
Total esatimted cost of improvement	35,368 25

Aggregate length of stream to be improved, so as to make it navigable about seven or eight months in the year, 134 miles.

COMMERCIAL STATISTICS.

Over 1,000 square miles of territory, containing a population of over 30,000 people, are entirely dependent on the successful navigation of this river for whatever of trade they have. This is computed at $2,125,000. This section is also placed among the finest agricultural districts in Tennessee. There are four steamers running in this trade.

* * * * * * *

It is claimed by many merchants and farmers that this trade will be fully doubled when they have uninterrupted navigation during the shipping season. The tariff on a bale of cotton to Memphis from this vicinity is $3, which, with the long-continued depression in the price of cotton, has operated against any full production. But with

the expectation of the removal of these causes, it is supposed that the acreage of cotton will be vastly increased.

Dyersburg and Eaton are the only towns on or near the river; the first had a population of about 4,000 and the latter of nearly 800; both are enterprising and will receive a great stimulus if the above improvements are made.

Very respectfully submitted,

ZEPH. HARRISON,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

P 39.

EXAMINATION OF "THE BAY," A TRIBUTARY OF SAINT FRANCIS RIVER, ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 10, 1881.

GENERAL: I have the honor to submit the following report upon the examination of "The Bay," a tributary of the Saint Francis River, Arkansas, in acordance with the provisions of the act of Congress approved June 14, 1880.

The location of "The Bay" is between Crowley's Ridge and the Saint Francis River. In high-water it connects with the Saint Francis in the Sunk Lands, near Lester Landing, Craighead County, and flows in a southerly direction, through Poinsett, and empties into the Saint Francis near Wittsburg, in Cross County. In low-water there is no connection with the lakes at the upper end, and the volume of water is due entirely to the drainage of Crowley's Ridge.

The examination was made by Mr. J. B. Rohrer, assistant engineer, upon the completion of the examination of the Saint Francis River from Greenville down. The party would have entered the stream at some point on its higher section, had there been any certainty of finding a channel through the swamps. As it was, they were compelled to start in at the mouth and ascend as high as the stage of water then existing would permit.

The bay at its junction with the Saint Francis is about 350 feet wide, gradually narrowing as we ascend the stream, until it finally becomes lost in the swamps. Though the whole country between Crowley's Ridge and the Saint Francis overflows at high-water, the bar, some 10 miles above its mouth, affords at low-water scarcely even 5 inches. At a point some 12 miles above the mouth, the river narrows to about 75 feet, with a general depth of about 6½ feet, but it is obstructed in many places in this stretch by snags, logs, leaning timber, &c.

Through the next 8 miles we find the stream with a width between banks varying from 50 to 100 feet, and depth varying from 3 to 10 feet, though in many places the channel is filled with tow-heads or islands, and also obstructed by snags, logs, &c. From this point up the channel becomes narrow and obstructed in like manner, until the water scatters through the timber, and no well-defined channel can be found.

To the lower 30 miles of the stream the name of The Bayou has been applied by the inhabitants about that limit, and through the swamps the stream is known as The Bay proper.

There are no farms along the entire length of the bay; the cultivated lands are back on the river and distant several miles.

Commercially, the stream is of no particular importance, and I can see no particular advantage to be derived by the general government in undertaking any improvement.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX Q.

REMOVING SNAGS, ETC., FROM THE ARKANSAS RIVER—IMPROVEMENT OF ARKANSAS RIVER BETWEEN FORT SMITH AND WICHITA AND AT PINE BLUFF; AND OF RIVERS SAINT FRANCIS, WHITE, L'ANGUILLE, FOURCHE LE FÈVE, SALINE, AND BLACK, ARKANSAS, AND CURRENT, MISSOURI AND ARKANSAS.

REPORT OF CAPTAIN THOMAS H. HANDBURY, CORPS OF ENGINEERS OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881 *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Little Rock, Ark., August 10, 1881.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river and harbor improvements under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant.

THOS. H. HANDBURY,
Captain Corps of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Q 1.

REMOVING SNAGS, WRECKS, ETC., FROM THE ARKANSAS RIVER.

This work was transferred to my charge by Maj. Charles R. Suter, Corps of Engineers, on the 1st of February last.

At that time the United States snag-boat C. B. Reese, with a full complement of officers and men, was engaged in the operation of removing snags, &c., from the lower reach of the Arkansas River.

Soon after this date, however, the backwater in the Arkansas, consequent upon a rise in the Mississippi, covered the snags so that work in that locality could no longer be carried on to advantage.

The captain was then ordered to work up towards Little Rock.

This place was reached on the 16th of February. In the mean time the Arkansas River also had risen to such an extent as to cover all the most troublesome snags in this vicinity. While awaiting the subsidence of this rise at Little Rock, the crew was employed in making some repairs to the boat that were found to be necessary.

On the 28th the boat left Little Rock, Ark., under orders to work between that point and Fort Gibson, Ind. T.

On the 20th of March it had reached Fort Smith, Ark. Between that

date and the end of April, the field of operations was in the Indian Territory.

About the middle of May it returned to Little Rock, and was laid up in ordinary awaiting a more favorable season for operations.

On this trip the boat was unable to get nearer to Fort Gibson than Webber's Falls, about 40 miles below.

The stage of water was not of sufficient depth while she was in that region to admit of a boat of her draught, 30 inches, going higher up. She draws full 12 inches too much for economical snagging work in the Arkansas River above Fort Smith.

The small wooden snag-boat that is now being built from the funds appropriated for the improvement of the Arkansas River, between Fort Smith, Ark., and Wichita, Kans., it is thought can be worked to greater advantage in this portion of the river.

This boat will soon be ready for work, and will be at once dispatched to that field of operations.

The Reese, however, is very well adapted to the work required of her, in the lower reaches of the river, and during the last season has rendered very efficient service.

The following is a summary of the work done by the *C. B. Reese* since the 1st of February last:

Snags pulled, 391, weighing 6,662 tons.
Drift piles removed, 23.
Trees cut, 346.

A greater portion of the season's work was done prior to February 1, the results of which should be found in Major Suter's report for this year.

Notwithstanding a great number of snags has been taken from the channel of this river, there are as yet a great many remaining, especially between Pine Bluff and the Mississippi River.

In the interests of the commerce of the river, these should be removed at as early a day as practicable.

Should the necessary funds be appropriated, a greater part of the work could be done in one or two seasons at farthest, with the appliances that we are now provided with.

When the river is once cleared of the old snags, which have been accumulating in its bed for years, a comparatively small yearly appropriation will suffice to remove from the channel those that from time to time appear and are troublesome.

In connection with the improvement of this river between Little Rock and its mouth, it is proper to call attention to the need of a reliable map of this reach.

Besides removing the snags which obstruct the channel of the river, there are other improvements that will be necessary as the country is settled up, and this outlet for its surplus products becomes more and more necessary to its prosperity, such as increasing the depth of water over shoal places, preventing undue erosion of the bank, and keeping the width of the river bed within limits commensurate with the volume of water flowing, and the depth of channel necessary for navigation.

To give this subject a comprehensive study, and be prepared to deal with it as its importance demands, it is necessary to have a proper survey of the river made, and to provide ourselves with all data bearing upon the subject.

In 1869 a survey of the Arkansas River from Fort Gibson, Ind. T., to Little Rock, Ark., was made, under the direction of Col. J. N. Macomb, Corps of Engineers, by S. T. Abert, civil engineer.

The notes and unfinished maps of this survey are now in my charge. These, together with Mr. Abert's published report, give full information relative to this portion of the river. For want of necessary funds these maps have never been completed for publication. It was the intention, it is believed, of the Engineer Department, at that time, that this survey should be extended to the mouth of the river.

No funds having been made available since then, for that purpose, the matter has remained in abeyence.

It is now suggested that it be again taken up, and that the attention of Congress be called to the propriety of making an appropriation for continuing this survey, as was originally intended, to the mouth of the river.

It is estimated that the cost of this survey, including making up of notes, and preparation of maps, will be about $75 per mile. The estimated distance from Little Rock to the mouth of the river is 278 miles, making the total cost, say, $21,000.

ESTIMATE FOR THE FISCAL YEAR ENDING JUNE 30, 1883.

Working expenses of snag-boat, including current repairs eleven months, at $3,000 per month	$33,000
For continuing survey of the Arkansas River, from Little Rock to its mouth.	21,000

COMMERCIAL STATISTICS.

The principal product of this country is cotton, with some lumber and coal. The lumber trade is growing rapidly, and the coal fields above Little Rock, in the valley of the Arkansas River, are being steadily developed.

With cheaper means for transportation, there is every reason to believe that this would grow into a profitable business.

With regard to cotton, I am credibly informed that it will be within limits to estimate the amount grown in the country contiguous to and naturally seeking the Arkansas River for transportation between Little Rock and Fort Smith at 130,000 bales, and the river cotton from Pine Bluff to the mouth at 30,000 bales, and we have a grand total of 160,000 bales. This, of course, is not all transported by water, but the river is its natural line of cheap transportation to market. Large quantities of cotton seed are also moved from these plantations to market. To this should be added a corresponding amount of increasing freight, such as merchandise, supplies, farming implements, machinery, &c., to supply the wants of the rapidly increasing population, attracted within its limits by its genial climate, great mineral resources, and fertile soil.

The work is situated in the collection district of New Orleans. The nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$35,000 00	
Amount appropriated by act approved March 3, 1881	25,000 00	
		$60,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		29,163 63
July 1, 1881, amount available		30,836 37
Amount that can be profitably expended in fiscal year ending June 30, 1883.		54,000 00

Q 2.

IMPROVEMENT OF THE ARKANSAS RIVER AT PINE BLUFF, ARKANSAS.

On the 1st of February last the charge of this work was transferred to me by Maj. Charles R. Suter, Corps of Engineers. At that time resurvey of the river in this vicinity was in progress with the object of ascertaining what changes had taken place since the date of the last survey, and to collect data so that the details of the general plan could be decided upon. This general plan has for its object the improvement of the navigation of the river in this vicinity to stop erosion which was taking place in front of the town, and on both sides of the narrow neck opposite, where a serious cut-off is threatened.

Upon the completion of this survey, which extends from Yellow Bluff to Rob Roy, a distance of 21 miles, and of some other necessary preliminary work, the actual work of revetting the right bank of the river in front of the town of Pine Bluff was commenced at Brump's Bayou. This was on the 8th day of March, 1881. This revetment is a continuous wire netting interwoven with brush, and is between 85 and 90 feet wide. It extended from the point named down to near the level, a distance of 3,900 feet, being put in place just previous to the spring rise, which brings with it large quantities of soil in suspension and sand rolled along the bottom. The effect of this peculiar form of revetment, owing to the projecting limbs and branches of the interwoven brush, is to check the velocity of the water so loaded and cause it to deposit a part of this moving soil and sand upon the revetment. This, in turn, crowds the main current towards the center of the channel and thus relieves the eroded bank. Thus far the results obtained at this point are very satisfactory. The shore to be protected is a bluff bank rising between 40 and 50 feet above the ordinary low-water of the river. It is composed of sand of various degrees of fineness, quicksand and sandy clay in not very well-defined strata. About 50 feet below low-water level there seems to be a pretty well-defined layer of hard clay. The thickness of this has not been ascertained; for our present purposes it was not deemed necessary to incur the expense.

After completing the revetment along the town front a similar work was commenced at the upper end of Yell's Bend, 4½ miles above. The object of this was to prevent further erosion of the upper side of the narrow neck where the cut-off is threatened. At the end of the year this had been carried down a distance of 3,700 feet from the place of beginning. This revetment was in character similar to that put in along the city front.

The bank in this locality is about 20 feet in height above low-water. It was first graded to a slope of 1 on 2 and the revetment then put on extending from top of the graded bank out under the bottom of the river. The low-water protection was 80 feet wide; high water 42. The principal part of this grading was done by the ordinary hand method for like work in sand. The small pump which had been procured for driving the piles for the curtain dike-work, was used for some time in the work of grading this bank, resulting in a reduction of fully 33 per cent. of the cost as by hand. The trouble was it was too small and could not do enough of the work required. For the work of the coming season it is proposed to procure more powerful appliances of this kind and do the necessary grading entirely by the hydraulic process.

About 2 miles below this revetment and on the same side of the river

there was built a wire curtain-dike projecting perpendicularly from the bank 580 feet; here there is an angle of 118° 30′. The dike then continues 530 feet down stream. The object of this structure is to cause a deposite of sand and suspended matter at this place during high-water which will force the low-water channel over to the right bank, inducing erosion where the water impinges. This can be followed up by similar structures lower down and the river finally forced to wash away the sand-bar under the right bank and build up one under the left. The channel will then be nearly in the position it occupied before the unfavorable changes in this locality took place.

It can readily be seen that such structures can be used with success only in sediment-bearing streams, the idea being to check the velocity of the current with them without stopping it suddenly and cause a deposit of part of the load that is being carried along. They are best put in just after the highest spring rise, when the greatest amount of earth is being carried down, and when the heavy drift, which would otherwise destroy them, has passed.

Under favorable circumstances a few days will suffice to so embed them in a sand-bar of their own making that the subsequent rises of the season will not destroy them. With this particular dike we have not been able as yet to get the effect that was expected. It was put in at a comparatively low stage of water after the first rise, in expectation of a second that usually takes place in June or July; at the end of the year this rise had not taken place. As the water in the Arkansas River becomes low there is little or no sediment carried in suspension, consequently no results are expected so long as the river is at a low stage.

For the details connected with this work and for descriptions of the appliances used in carrying it on, I would respectfully refer to the very interesting report, herewith submitted, of my assistant, W. H. Byram, who has been in local charge of the work during the past season.

It is proposed, with the funds now available, to continue this work of improvement according to the general plan already approved. During the coming season the revetment in Yell's Bend will be continued down a distance of about 3,000 feet. About 5,000 feet of the left bank of the river on the lower side of this same neck of land will be similarily revetted, and works will be put in for the rectification of the channel.

For commercial statistics, port of entry, and collection district, see report for improving Arkansas River, removing snags, wrecks, &c.

Total amount appropriated for this work $48,000

Money statement.

July 1, 1880, amount available	$25,000 00	
Amount appropriated by act approved March 3, 1881	23,000 00	
		$48,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	19,851 89	
July 1, 1881, outstanding liabilities	4,160 07	
		24,011 96
July 1, 1881, amount available		23,988 04
Amount (estimated) required for completion of existing project		52,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		52,000 00

REPORT OF MR. WILLIAM H. BYRAM, ASSISTANT ENGINEER.

PINE BLUFF, ARK., *July* 15, 1881.

CAPTAIN: I have the honor to submit the following report of operations for improving the Arkansas River at Pine Bluff and vicinity during the fiscal year ending June 30, 1881:

These operations have been carried on in accordance with the general plan as submitted by yourself and printed in Senate Ex. Doc. No. 67, Forty-sixth Congress, second session. The objects therein proposed were three in number, viz:

1st. To protect the river bank immediately in front of the town from further erosion.

2d. To rectify the course of the river in bend above the town, in order to remove a bar now existing there, which is an impediment to navigation; and also, by diminishing the curvature of the bend, to lessen the tendency to excessive scour in front of Pine Bluff.

3d. To prevent the formation of a cut-off now threatened across the neck of the peninsula opposite Pine Bluff, which, if allowed to take place, will leave that town nearly 4 miles from the river, and will have injurious effects on the river above and below.

The whole improvement will extend over about 13 miles of the river.

The survey was begun in November, 1880. The reach to be studied consisted, as per instructions from Maj. Charles R. Suter, Corps of Engineers, U. S. A., of that portion of the river "extending from about the Yellow Bluff, above the town of Pine Bluff, down to Rob Roy below, a distance of about 21 miles.

A single system of thirty-eight triangles was extended over the entire reach; the angles being carefully determined by a stackpole transit. The triangulation stations were located with a view to permanence, and were marked either by pieces of $1\frac{1}{4}$ inch gas-pipe, anchored with a block of cement, or by heavy cypress hubs. The maximum discrepancy in closing triangles was fixed at 10 seconds, and the mean discrepancy was less than five seconds.

The triangulation was commenced November 22, and completed January 8.

The low-water survey was commenced January 24 and completed February 7.

The low-water hydrographical survey was begun April 11, and completed April 14. Low-water soundings were made over forty ranges, put in at characteristic points, and including the entire reach.

REVETMENT ALONG THE TOWN FRONT.

The city of Pine Bluff is situated on the right bank of the river, and on a bluff which at low-water is about 45 feet high.

A special study, by cross-sections and borings, was made of the river and bank along the town front, to determine the limit of scour, and thereby the character and width of a revetment required to prevent further erosion.

Eight series of soundings, at greatly varying stages of the river, were taken over ranges about 500 hundred feet apart extending from △ Cainy to White's Bayou.

On a rising river very rapid scour was observed. Seven borings were made at various points between Brump's and 500 feet below the levee, to determine the nature of the substrata and the extent of the underlying beds of quicksand.

In boring No. 4 on range D there was found at a depth of 90 feet from top of bluff a very hard tenacious clay, which it is believed determined the limit of scour. This depth was reached by the river this season at only one point, the gauge at that time indicating 24.5 feet, and the maximum sounding being 65 feet.

Above this layer of clay heavy strata of quicksands were encountered. These strata were not continuous, but occurred in the different borings at greatly varying depths, the maximum thickness being 20 feet.

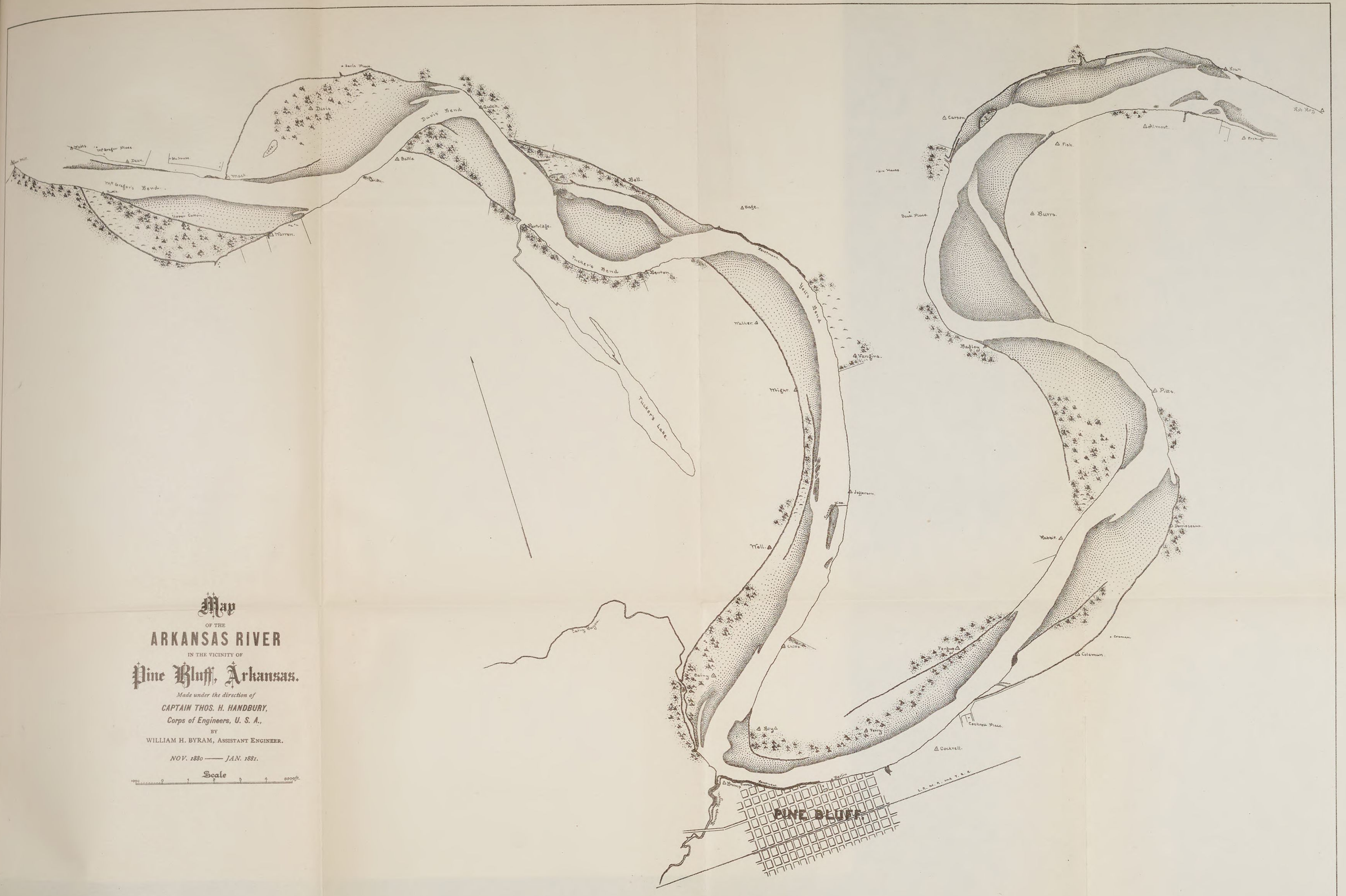
It was thought that a protection consisting of a brush and wire mattress 80 feet wide put in at an average stage would be amply sufficient. The form of mattress decided upon consisted of a wire netting to be made continuously, and into which the brush could be wattled or woven in such a manner as to form a strong and at the same time a very flexible mattress.

The mattress boat used was in the form of an ordinary flat, 80 feet long, 16 feet wide, with guards $3\frac{1}{2}$ feet wide. Upon this flat was a system of inclined ways, a working platform, and a skeleton drum, on which was made the wire netting.

The method of working was as follows:

The boat was moved at right angles to the current, with the lower ends of the ways up stream. The wire drum was 2 feet 6 inches in diameter and 80 feet long; the wire was led directly to the drum from coils lying on the deck. On the drum was a number of pins which determined the angles of the hexagonal mesh of the netting. As each pair of wires are brought together about a pine, it was given a number of twists, forming the fastenings, which were very strong and easily made.

Throughout the entire length of the mattress there were five longitudinal tension wires, those on the edges being of No. 10 wire, and the intermediate ones of No. 12 wire.



Map

OF THE

ARKANSAS RIVER

IN THE VICINITY OF

Pine Bluff, Arkansas.

Made under the direction of

CAPTAIN THOS. H. HANDBURY,

Corps of Engineers, U. S. A.,

BY

WILLIAM H. BYRAM, ASSISTANT ENGINEER.

NOV. 1880 —— JAN. 1881.

Scale

1000 0 1 2 3 4 5000ft.

The wire used for the netting was No. 14. The finished netting was passed directly to the ways and into the meshes; the brush was "wattled" by weavers standing on the working platform, which was about 20 inches below the ways.

The brush was woven in with the butts up stream, the alternate pieces being placed nearly at right angles with each other, and at an angle of 45° with the direction of the current.

The shore fastenings were made of No. 10 wire about 10 feet apart, and were secured to heavy stakes driven about 20 feet back from the edge of the bank.

Each alternate shore wire was passed through the entire width of the mattress and was secured at the edges and at intermediate points to large pieces of brush. The other wires were passed 40 feet into the mattress and well secured.

An almost constant motion was given to the boat by means of lines from each end of boat passing down stream.

The mattress was continually paid off from the up-stream end of the ways. The brush being of hard wood, and aided by the pressure of the current and accumulation of sediment, sunk immediately to the bottom.

The work was commenced March 8 and completed April 4. A total of 3,900 feet of mattress was put in in nineteen working days; average day's work 205 feet.

The average number of men employed in the actual construction of the revetment was 18, and the rate of pay 17½ cents per hour.

The best result was obtained on March 30, when 345 linear feet of revetment was put in by twenty men, or an average of 17¼ feet per man, working ten hours. This is equivalent to 1,380 square feet of mattress per man, working ten hours.

The bush used consisted of oak, pine, gum, and hickory.

The expense of hauling the brush after it was delivered on the bank was necessarily great, owing to the unusual height of the bank, which was, during the progress of the work, from 35 to 40 feet.

	Feet
Total length of revetment	3,900
Width	80
Area	312,000
Average run per day	205
Number of working days	19
Average number of men employed per day	18
Average number of linear feet made per day per man	11.4
Greatest number of linear feet made per day per man	17.25

OPERATIONS IN YELL'S BEND.

Before commencing the mattress work at this point it was necessary to grade the bank to a proper slope to receive the high-water protection.

The grading was done partly by hand and partly by the hydraulic process. The pump used for the hydraulic grading was a Worthington duplex steam pump, having the following dimensions: Steam cylinder, 7½ by 10 inches; water cylinder, 4½ by 10 inches, and 2½-inch discharge.

The bank to be graded was about 23 feet high, and it was given a slope of 2 horizontal to 1 vertical.

Two thousand seven hundred and eighty-eight feet of bank was graded by hand, and 912 feet by water.

Grading.

	Hydraulic.	Hand.	Total.
Number of linear feet of bank graded	912	2,788	3,700
Number of cubic yards of earth removed	9,467	27,944	37,411

The mattress work put in here was similar to that put in along the town front, and was made on the same boat, the only difference being that in this mattress the brush was placed with the butts down stream, instead of up stream.

The brush is more easily handled and can be woven more firmly with the butts down stream; the small branches and twigs are also held up by the currents and act better as silt catchers.

Owing to a sudden rise which took place on the night of the 26th of May a portion of the mattress which was floating was caught by the drift and torn from the bank.

The total number of feet of mattress work put in was 5,940, of which 2,200 feet was washed out, leaving 3,740 feet.

The best day's work was on May 21, when 136 hours' labor completed 325 feet of mattress in ten hours; this is equivalent to 23.9 feet per man per hour.

The high-water protection was constructed as follows:

The shore fastenings which secured the mattress to the bank were placed 5 feet apart. Every third one was of No. 10 wire and extended through the entire width of the mattress; the others were of No. 12 wire. Across these wires, and fastened to the edge of the mattress every 5 feet, were No. 14 wires, which were carried to the top of the bank at an angle of 45°.

These wires, together with the shore fastenings, formed a netting with triangular meshes. Into this netting the brush was woven in a manner similar to that employed on the mattress boat.

The average width of the high-water protection was 42 feet.

HIGH-WATER PROTECTION.

Total length, in feet	3,675
Average width, in feet	42
Total area, in square feet	155,590
Number of working days	8
Total number of pounds of wire used	2,920
Total number of cords of brush used	300
Average number of linear feet made per day	459
Average number of men employed	22
Average number of linear feet per day per man	21.2
Average number of pounds of wire used per linear foot	0.79+
Average number of cords of brush used per linear foot	0.08

COMPLETED REVETMENT.

	Feet.
Length	3,740
Width	122

SUMMARY OF REVETMENT, LOW-WATER PROTECTION.

Total length, in feet	5,940
Washed out	2,200
Number of feet remaining	3,740
Width, in feet	80
Area, square feet	299,200
Number of working days	36
Total number of pounds of wire used	9,973½
Total number of cords of brush	1,279
Average number of linear feet made per day	165
Average number of men employed	13
Average number of linear feet per day per man	13
Average number of pounds of wire per foot	1.68
Average number of cords of brush per foot	0.22

WIRE-CURTAIN DIKE, YELL'S BEND.

The object of this dike was to rectify the course of the river above the town, by causing it to be deflected to the right bank, and, by cutting away a portion of the shore bar existing there, form a new shore line with much less curvature.

The dike was the kind known as wire-curtain dike, it being constructed of a wire netting or curtain, supported on a row of piling.

The piles were of cottonwood, about 10 inches in diameter at the large ends, and were sunk by means of the water jet to a depth of from 10 to 12 feet.

The total length of the dike was 1,110 feet, being in two parts as follows:

Shore connection 580 feet long, starting from a point 508 below △ Jefferson, and being at right angles to the bank.

From the outer edge of this part of the dike commenced the trailing portion, 530 feet long. This made an angle of 118° 30′ with the shore connection and was nearly parallel with the proposed shore line of the opposite side.

The piles were sunk in two rows about 6 feet apart and were then drawn together, crossing each other at the height desired for the waling pieces and secured by lashing of No. 10 wire.

The waling pieces were secured in the intersection of the piles by drift bolts. The pairs of piles were placed 12 feet apart, and the waling pieces were placed 18 feet above the zero of the gauge or about 14 feet above low-water.

One hundred and forty-six piles were sunk. The apparatus used was crude and considerable time was lost getting the piles raised up in position. After being in position the time required to sink them was not more than two or three minutes.

The wire netting was made on a boat which was placed at right angles to the line of the piling.

The netting was thirty feet wide and was made continuously the boat moving from under the net as fast as it was made.

The mesh was an elongated hexagonal, 18 inches by 12 inches, made of No. 14 wire.

The anchors were gunny sacks filled with sand and were placed every 12 feet and securely fastened to the lower edge of the net.

From each anchor a No. 10 tension wire was passed through the netting and secured at the top to the waling piece. It was found that one man could make the twists necessary for 360 square feet of net in ten hours.

SUMMARY OF CURTAIN DIKE.

Dike begun June 1. Completed June 30.

Total length in feet	1,110
Total width in feet	30
Total number of piles and waling pieces used	191
Number of anchors used	90
Average weight of anchors used, poumds	300

CONCLUSION.

At this time it is impossible to say what effect will be produced by the dike.

The dike was put in with the expectation that there would be a big rise in June, but our expectations were not realized, there being no rise high enough to cover the piling. Considerable silting in has, however, taken place but not sufficient to produce any effect.

The mattress work along the town front has become well silted in and seems to have the desired effect.

The revetment in Yell's Bend is all intact, but requires high-water to silt it in.

I desire to express my appreciation of the valuable assistance which I have received from Mr. F. W. Tuttle and also the services of others of my party.

Very respectfully, your obedient servant,

WM. H. BYRAM,
Assistant Engineer.

Capt. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

NOTES ON DRAWINGS.

DESCRIPTION OF MATTRESS BOAT, PLATE I.

The boat used for this work was an ordinary flat, 80 feet long, 16 feet wide, with guards 3½ feet wide. A system of sixteen inclined ways of 2-inch and 4-inch oak, set on edge 5 feet apart, served as a frame-work on which to build the mattress.

The lower end of the ways were secured to the edge of one guard, and the upper ends were supported on posts 5½ feet above the deck as the boat lay in position at right angles to the bank, the lower ends of the ways up stream.

On the down-stream side of the boat, and 6 feet 4 inches above the deck, was a platform 7 feet wide, extending the entire length of the boat; under the platform was the drum, on which was made the wire-netting. This drum was 2½ feet in diameter and 80 feet long, made in sections about 12 feet long, each section revolving independently of all the others. The object of the drum being made in sections was to enable the netting to be made faster on one side than on the other, that the boat might more easily follow any irregularities of the bank.

The drum was composed of 8 longitudinal ribs, arranged in pairs, as shown in detail drawing, Plate No. IV, Fig. 1.

Each of these ribs carried a uumber of pins made of three-sixteenth-inch iron wire, 4 feet apart, longitudinally those in the same pair of ribs being opposite each other and midway between those of the alternate pairs.

The size of the mesh depends on the diameter of the drum and on the distance apart of the pairs on the ribs. In this instance the mesh was 3½ by 4 feet, with the twisted side of 4 inches. Assuming the net to be in process of construction, the method of making the mesh was as follows:

The two wires at pins A and B, Fig. 1, Plate IV, are brought across one another at pin C, and then below D, where they are held by the left hand, while with the right hand the twist is made by inserting a pin ⅜ by 8 inches between the two wires at C and D, and making four or five turns.

The twist complete is shown at G. The wire was led to the drum from coils lying on the deck.

It was determined by trial that a man could make about four complete fastenings per minute. The finished netting passed directly to the ways over a piece of 4 by 4 inch pine, secured to the upper ends of the ways.

The brush was placed with the butts up stream, and at an angle of 45° with the axis of the stream. The alternate pieces of brush were placed perpendicular to one another, and over one and under the next, forming a sort of basket-work.

It is believed that with this method almost any desired thickness of mattress can be made.

Under favorable circumstances it is thought possible to complete at least 500 feet per day.

DESCRIPTION OF PILE-DRIVING BOAT, PLATE II.

The boat used for this purpose was 75 feet long and 20 feet wide on the deck. The boat was furnished with a portable "New Era" boiler of 15 horse-power, and a Worthington Duplex steam pump, with 7½ by 10-inch steam cylinder, and with 4½ by 10 inch water cylinders, 2½-inch discharge pipe.

The method of attaching pile pipe and nozzle is shown in Plate IV, Figs. 4 and 5.

CURTAIN DIKE BOAT.

The boat used for this work was a flat 50 feet long and 12 feet wide, with guards 2½ feet wide. On the deck was placed the wire drum, which was constructed as shown, Plate IV, Fig. 2.

The core of the drum was an octagonal piece of pine 4 inches in diameter and 30 feet long. On each of the right sides of this piece there was a longitudinal rib of pine 1 foot by 6 inches, making the drum 28 inches in diameter and 30 feet long.

On each of these ribs was a number of iron pins placed in pairs, 12 inches apart, the pins of each pair being 4 inches apart.

The pairs of pins on each rib were opposite the space on the adjacent rib, each alternate rib being alike.

Around the drum and at each row of pins was placed a hoop of iron to give strength to the whole machine. The drum was supported so as to revolve freely, being supported at each end and also in the middle.

The space between the pins of each pair was cut out, giving room for the twisting pin to turn.

The method of working was as follows: Two No. 12 wires for selvage were led to the drum at each end. A man then takes a part of a coil of No. 14 wire, and securing the end to one of the No. 12 wires, passes along putting the wire in a zig-zag manner on the pins of the two adjoining ribs. On the return the wire would be passed over the pins of one rib just used and also over those on the next rib.

The wires are now in a position to be twisted, which was done by putting a pin of ⅝ by 8 inch iron between the two wires lying close together and giving it four or five complete turns.

The completed twist is shown in Fig. 3, Plate IV.

WM. H. BYRAM,
Assistant Engineer.

Q 3.

IMPROVEMENT OF THE ARKANSAS RIVER BETWEEN FORT SMITH, ARKANSAS, AND WICHITA, KANSAS.

The charge of this work was transferred to me on the 1st of February last, by Maj. C. R. Suter, Corps of Engineers.

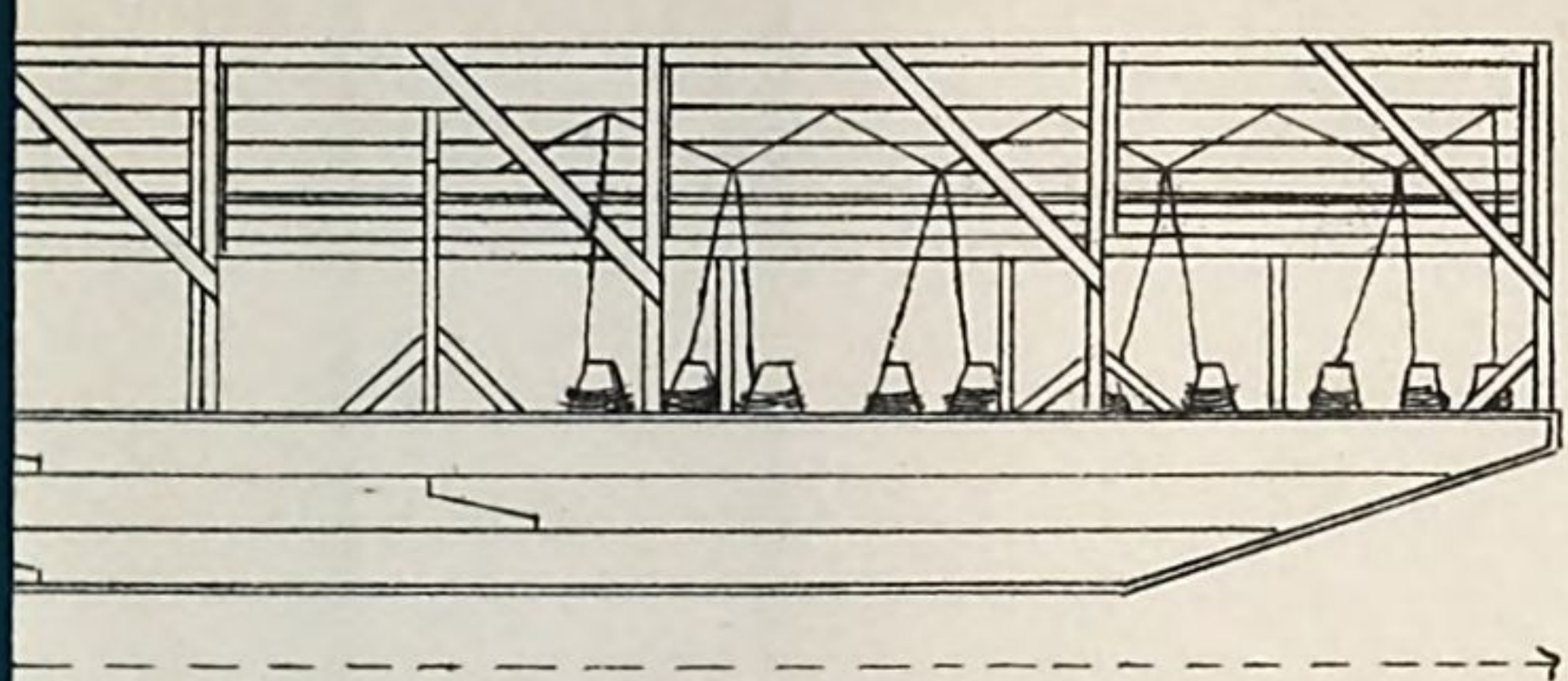
At that time active field operations were in progress on that part of the river lying between Wichita and Arkansas City, Kans.

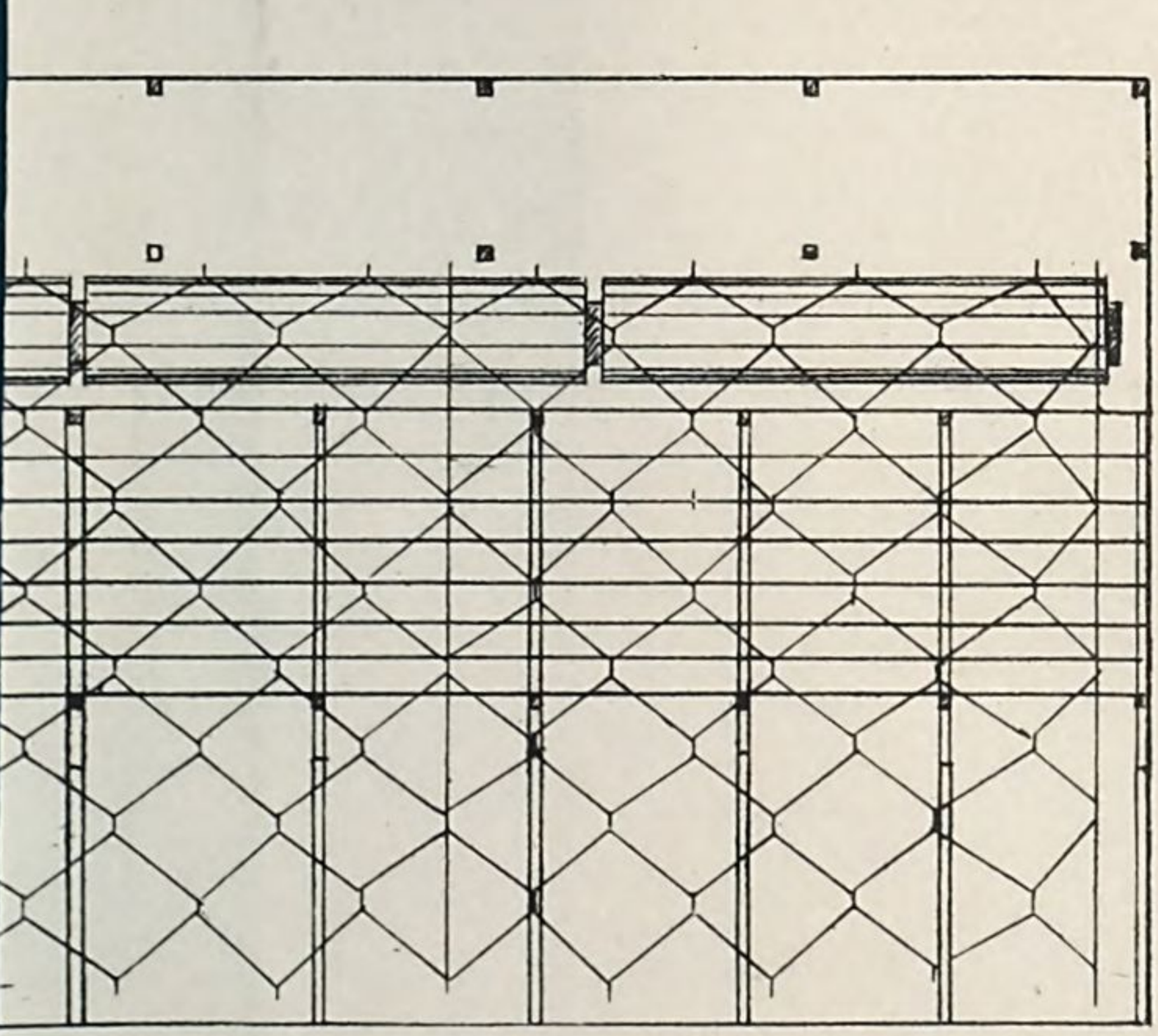
Soon after this date, however, on account of high-water, and unfavorable weather, these operations were suspended.

From the experience gained in this short season of active operations, it became apparent that for successful and economical work over the



PLATE. I.





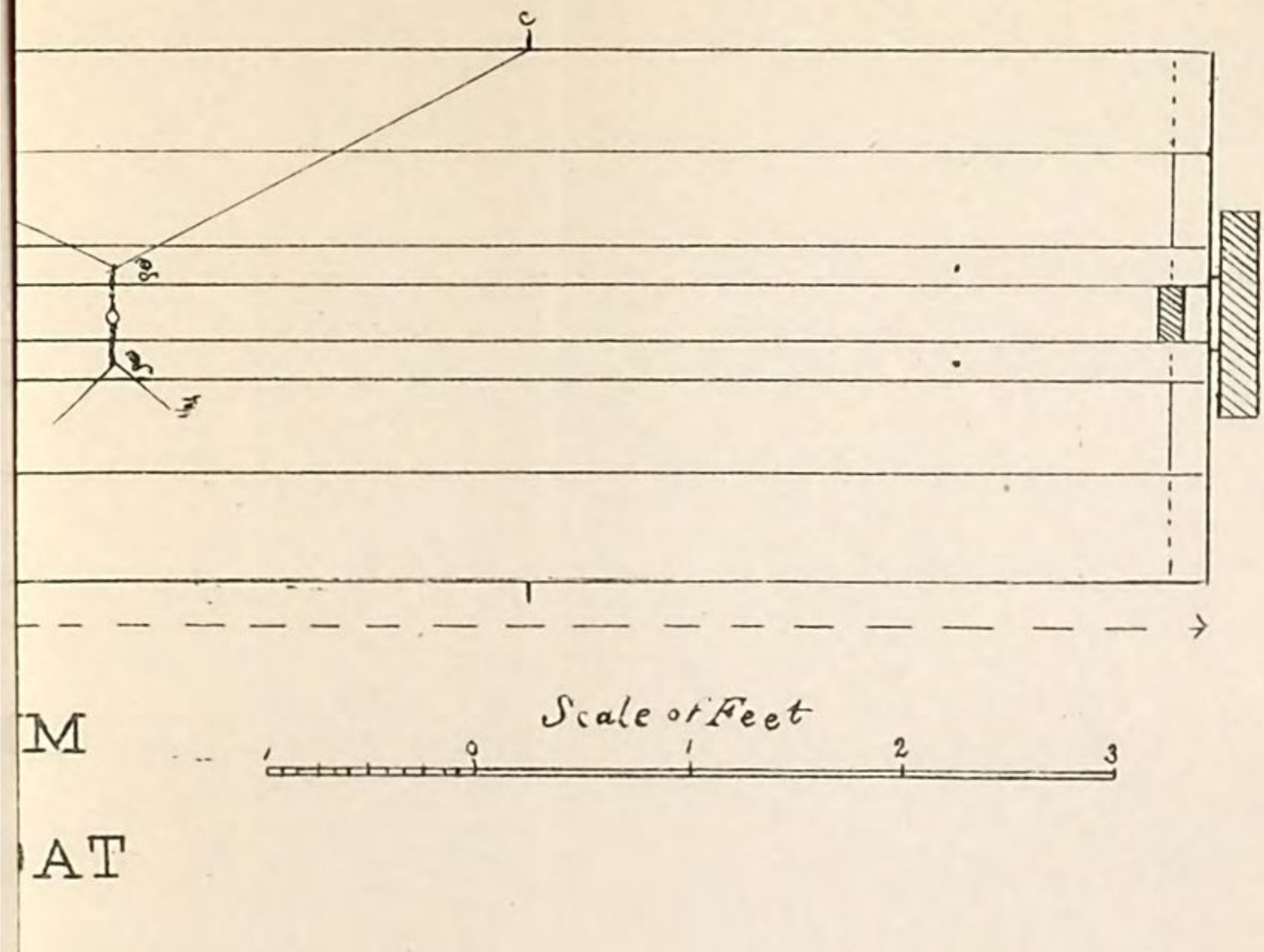
Scale of Feet.

0 5 10 15 20

PLATE II

PLATE III

PLATE IV



M

AT

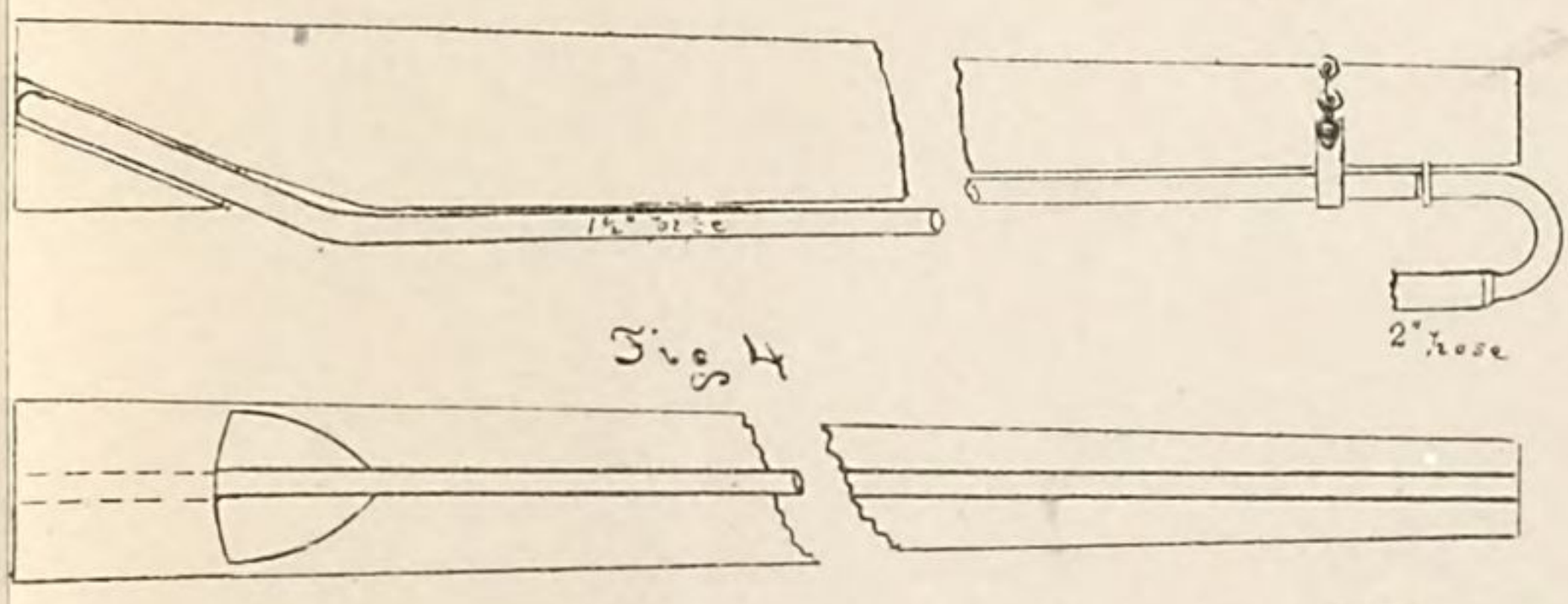
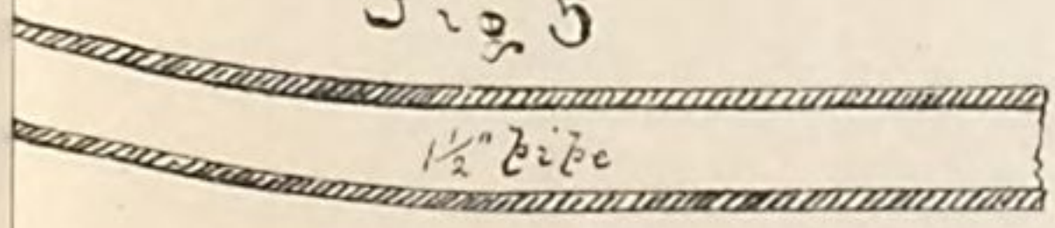
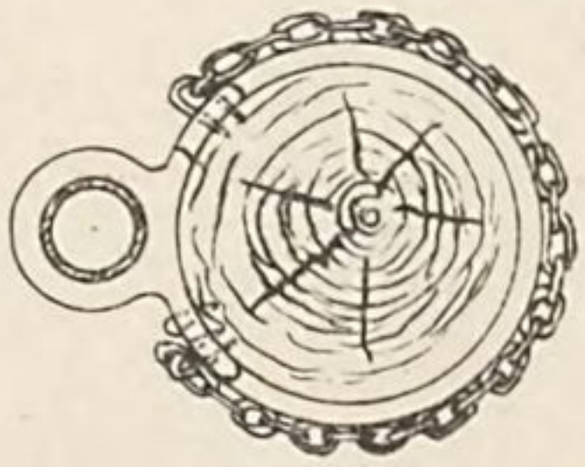


Fig 4

Fig 5





PILE SINKING

Detail of

PILE and NOZZLE

300 miles of river below, extending to Fort Smith, more suitable appliances than we were working with would have to be provided.

A large number of snags, some rocks, and many boulders are to be removed.

Upon my representation of this necessity to you, I was authorized to construct a strongly built, decked scow boat, drawing about 12 or 14 inches of water, supply it with suitable propelling power, and appliances for removing these obstructions.

The construction of this boat was commenced at Little Rock, Ark., early in May, and it was expected to have it ready to take the field about the middle of July. Owing, however, to a delay in the construction of the machinery, caused by labor difficulties, it will not be finished probably until a month later. At the end of the fiscal year the hull was ready to be launched, in a completed state, the cabin lumber all gotten out ready to be put together, and the machinery in a satisfactory state of advancement, considering the labor difficulty above alluded to.

It is proposed that this boat shall be finished with all possible dispatch, and at once sent to Arkansas City, Kans.

On her way up the river she will remove only such obstructions as interfere with her own passage, it being presumed that any boats wishing to go up this season can follow after her.

Upon her return down, however, the obstructions will be more carefully removed. The boat will be kept in the field as long as the funds available will admit, the idea being to open a passage by water as speedily as possible to a ready market for the surplus products of the country bordering upon this reach of the Arkansas River.

In order to carry on the work of this character that is needed, an appropriation of at least $30,000 will be necessary for the year ending June 30, 1883.

This improvement, it will be seen, only contemplates giving temporary and immediate relief to the commerce of this portion of the river.

As this country becomes more and more settled, and its rich mineral and agricultural resources become more developed, the wants of its commerce will demand that the river be made navigable for a greater number of months throughout the year, and that the works of improvement be of a more permanent, and consequently more costly character.

In order that this subject may receive the attention and study that its importance demands, it will be necessary that a reliable survey of the river be made, extending from Fort Gibson, or the mouth of the Grande River, Indian Territory, to Wichita, Kans., connecting with and forming a continuation of the survey from Fort Gibson to Little Rock, Ark., made under the direction of Col. J. N. Macomb in 1869.

Such a survey has been recommended by my predecessor in charge of this work in his annual reports for the last two or three years. In his recommendation and estimate of $16,300 for this survey, I fully concur, and suggest that the attention of Congress be called to the propriety of making an appropriation of this amount for this purpose.

For statistical information bearing upon this improvement, I would respectfully refer to the subjoined copy of a letter, kindly furnished me by the Hon. W. M. Fishback, member of the Arkansas State senate, residing in Fort Smith, Ark.

The work is siutated in the collection district of New Orleans. The nearest port of delivery is Memphis, Tenn.

Total amount of appropriations $59,000 00

Money statement.

July 1, 1880, amount available	$16,408 25	
Amount appropriated by act approved March 3, 1881	24,000 00	
		$40,408 25
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		10,333 51
July 1, 1881, amount available		30,074 74
Amount that can be profitably expended in fiscal year ending June 30, 1883.		46,300 00

COMMERCIAL STATISTICS.

FORT SMITH, *August* 3, 1881.

DEAR SIR: Yours of the 1st instant to Col. L. H. Roots, referred to B. Ban & Co., and by him referred to me for reply, just at hand.

In the absence of any accurate statistics, I can only give estimates from conversation with our business men.

There are shipped from this place, by boat or rail, cattle, sheep, hogs, cotton, peltries, wheat, hard lumber, pecans, ginseng, snake root, Seneca-root, &c. Of cotton we ship by rail this year, up to date, about 24,000 bales, about 4,000 of which come from the Indian Territory.

If the increase of shipment continues from the latter for the next five years at the same rate as for the past two years they will ship 25,000 bales themselves. This is exclusive of what goes by other means and other routes than by Little Rock and Fort Smith Railroad. We ship annually about 1,000,000 pounds of hides and peltries, five-eighths per cent of which comes from the Indian Territory. We have brought from the Indian Territory, or shipped from there, about 5,000,000 feet of hard lumber (walnut, ash, and oak); cattle, hogs, and sheeep are, for the most part, driven on foot and in immense numbers.

There are handled in this city at least 1,250,000 sacks of flour every year, all of which would come from Kansas, either in flour or in grain, if we had cheap transportation thence. The other articles are in less important quantities.

Now if we had river communication with Kansas, my own experience justifies me in saying that if we had cheap transportation between here and Southwest Kansas, we would find it to our advantage to purchase all the wheat and flour and beef from that region where they can be produced with so much less cost and give our attention to that species of produce which we can furnish at so much less cost than they.

We have unlimited quantities of coal and lumber, and are remarkably well adapted to cotton and sheep raisng, but are not adapted to wheat or extensive grazing. This interchange of productions would increase with indefinite rapidity, and seems to demand early and cheap means of intertransportation.

The country along the bank of the Arkansas River from Fort Smith to Kansas is settling rapidly, and if they had sure means of transportation, there is no estimating the increase of trade. The country is of unsurpassed fertility, but as yet a comparative wilderness. There is no place in the United States, in my judgment, where the United States could put in a million dollars with more profit alike to the nation and to the immediate vicinity.

Very truly,

W. M. FISHBACK.

Capt. THOS. H. HANDBURY.

Q 4.

IMPROVEMENT OF THE WHITE AND SAINT FRANCIS RIVERS, ARKANSAS.

The charge of this improvement was transferred to me in February last by Maj. W. H. H. Benyaurd; at that time the appropriation was exhausted, and work was suspended.

With the $8,000 appropriated by Congress at its last session for this work, it is proposed to continue the operation of removing snags and other obstructions from these streams, making use of the snag-boat already provided for that purpose. In this connection it might be

proper to call attention to the fact that this boat is not adapted for service in the upper reaches of these rivers.

In the Saint Francis it can work to advantage, probably as high up as Madison, about 100 miles from the mouth of the river, and in the White, up to J cksonport, at the mouth of the Black River. Above these points it is therefore necessary to make other provisions for removing obstructions to navigation.

In the upper reaches of the Saint Francis River it is thought that a strongly built decked scow, drawing not more than 10 or 12 inches of water, and properly supplied with suitable appliances for removing snags, overhanging trees, logs, and other obstructions to navigation, could be worked to very great advantage. Such an outfit would cost about $4,000. Its running expenses would be about $1,500 per month, and it could be worked to advantage for about eight months in the year.

ESTIMATED FOR THE FISCAL YEAR ENDING JUNE 30, 1883.

Working expenses of snag-boat, including incidental repairs, 6 months, at $3,000 per month	$18,000	
Expenses in ordinary and general repairs	2,000	
		$20,000
Outfit for Upper Saint Francis	4,000	
Working expenses of same eight months, at $1,500 per month	12,000	
		16,000
Total		36,000
Total amount of appropriations		$142,000 00

The improvement is situated in the collection district of New Orleans. The nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$12,000 00	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		11,821 93
July 1, 1881, amount available		8,178 07
Amount that can be profitably expended in fiscal year ending June 30, 1883.		36,000 00

COMMERCIAL STATISTICS.

From the most reliable statistics that I have been able to collect upon this head, I learn that there were shipped out of the Saint Francis River, by river last season, which was much below an average one, about 20,000 bales of cotton, 1,000 tons of cotton-seed, 500,000 feet of walnut lumber, and a considerable quantity of other less valuable lumber. By the same means there has been shipped into this country about 6,500 tons of general merchandise, supplies, &c.

With regard to White River I have been unable to get any definite information, but it is well known that it has an extensive commerce, both going out and coming into the country, dependent upon it for transportation. The country is rapidly settling up with a population that is developing its resources.

Q 5.

IMPROVEMENT OF WHITE RIVER, BETWEEN JACKSONPORT AND BUFFALO SHOALS, ARKANSAS.

In February last I relieved Maj. W. H. H. Benyaurd of the charge of this work. At that time operations in the field were suspended. In

June they were again resumed. The gravel and brush dam at the lower end of Arnold's Island, which was in process of construction at the close of last season, was completed by the addition of 300 entire yards of gravel and 350 cords of brush.

This dam does all that was expected of it. It has very materially increased the depth of water over a shoal at this place, which formerly gave great trouble to steamboat pilots.

At Maginnis's Shoal, about 1 mile below Arnold's Landing, work was resumed. A wing-dam is being built connecting into the outer edge of the dam built last season, and is to extend down stream about 230 feet. About 100 feet of this was completed at the end of the month.

Preparations were also made for resuming the snagging operations at an early day.

The amount of funds at present available for the improvement of this portion of White River being so exceedingly limited, the interests of navigation seem to demand that it be expended between Jacksonport and Batesville, where the larger part of the river commerce is carried on. Above Batesville improvements are necessary, but the want is not so pressing as below.

The work during the coming season will be confined to improving Saffold's Shoals, Haggletooth Shoals, and removing the most troublesome snags between Batesville and Jacksonport.

This accomplished, the funds will be exhausted, and this reach of the river, about 40 miles in extent, will be in very fair navigable condition.

From Batesvile to Buffalo Shoals, however, a great deal of the same general character of work is yet to be done before the river can be said to be even in a passably good condition.

The country is being rapidly settled up, and every year adds to the necessity for providing means for transporting the surplus products to market.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Total amount of appropriations $23,000

Money statement.

July 1, 1880, amount available	$7,213 29	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$15,213 29
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		7,732 98
July 1, 1881, amount available		7,480 31
Amount that can be profitably expended in fiscal year ending June 30, 1883.		20,000 00

Q 6.

IMPROVEMENT OF WHITE RIVER, ABOVE BUFFALO SHOALS, ARKANSAS.

In February last I relieved Maj. W. H. H. Benyaurd of the charge of this work. At that time no work had been done under the last appropriation, and none has been done since. It is proposed, however, to commence operations in this region early in July, and to push them forward to the extent of the funds available.

This portion of the river being but a succession of rocky shoals, it is not expected that any improvement short of locks and dams will make it available for navigable purposes during low-water.

As the expense of these would be entirely out of proportion to the amount of commerce to be at present benefited, their construction has not as yet been taken into serious consideration.

It is proposed to expend the amount at present available in endeavoring to so improve these shoals by removing loose rocks, blasting off ledges, building wing-dams, and removing snags and over-hanging trees, as to make them available for navigable purposes at least during high and medium stages of water. Even this would be a great benefit to the rich country roundabout that has absolutely no outlet, save the ordinary country roads, for its surplus products.

There is a growing and productive region of country around Yellville and Mountain Home that is very much in need of an outlet of this character.

The amount appropriated will be expended, so far as it will suffice, in improving the first 20 miles above Buffalo Shoals, in the manner above indicated.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	291 67
July 1, 1881, amount available	19,708 33

Q 7.

IMPROVEMENT OF THE SAINT FRANCIS RIVER, BETWEEN WITTSBURG AND LESTER LANDING.

The charge of this work was transferred to me by Maj. W. H. H. Benyaurd in February last, with the appropriation substantially expended. Congress, at its last session, not having made any additional appropriation for this portion of the Saint Francis River especially, no work will be done during the coming season. The proportion of the $8,000 appropriated for the improvement of the White and Saint Francis rivers that will be applicable to the Saint Francis River is so exceedingly limited, and the need of work upon the lower reach of the river so great, that none can be done above Wittsburg.

Money statement.

Amount appropriated by act approved March 3, 1881	$5,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883, see Appendix Q 4.	

Q 8.

IMPROVEMENT OF L'ANGUILLE RIVER, ARKANSAS.

In February last I relieved Maj. W. H. H. Benyaurd of the charge of this improvement. At that time work was suspended, and was not resumed at the end of the fiscal year.

The funds at present available for this work will be expended in removing snags, leaning trees, and other obstructions to navigation, and it is thought will be sufficient to place the stream in good navigable condition for several years.

No further appropriation, therefore, is asked.

Total amount appropriated	$17,000 00

Money statement.

July 1, 1880, amount available		$7,004 02
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		2,352 29
July 1, 1881, amount available		4,651 73

Q 9.

IMPROVEMENT OF FOURCHE LA FÈVE RIVER, ARKANSAS.

In February last the charge of this improvement was turned over to me by Maj. W. H. H. Benyaurd, Corps of Engineers. At that time work was suspended, the entire appropriation having been expended.

With the $3,000 appropriated by act of Congress approved March 3, 1881, it is proposed to hire a boat, with the necessary machinery, and employ hired labor to continue the removal of obstructions from this stream, as far as this sum will suffice.

There is a fertile and growing tract of country included in the valley of this stream, and depending upon it for means of cheap transportation. Many emigrants, attracted by the fertility of its soil, are settling in this valley.

Last season from 1,000 to 1,500 bales of cotton were brought out by the Fourche; also quite considerable quantities of lumber, shingles, live stock, hides, &c.

A corresponding amount of ingoing freight, such as merchandise, supplies, farming machinery, &c., is now transported by the river.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$4,799 74	
Amount appropriated by act approved March 3, 1881	3,000 00	
		$7,799 74
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		4,799 74
July 1, 1881, amount available		3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,000 00

Q 10.

IMPROVEMENT OF SALINE RIVER, ARKANSAS.

The charge of this work was transferred to me in February last by Maj. W. H. H. Benyaurd, Corps of Engineers. At that time work was suspended, and has not been resumed up to the end of the fiscal year.

It is proposed during the coming season to expend the remaining balance of the old appropriation, and the $5,000 appropriated by act of Congress approved March, 1881, in continuing this work, as far as the funds will suffice, between Mount Elba and the mouth of the river.

For the coming season, a strong flat-boat will be built, and supplied with sheaves, a steam capstan, tackle, saws, axes, &c., for the use of the party. The increased depth of the water, as the lower reaches of the river are attained, render such an outfit necessary. The boat will also furnish quarters for the men.

It is estimated that during last season about 10,000 bales of cotton were shipped by water from the plantations along this river, and had the river been in a more navigable condition it is thought that nearly double this amount would have been transported.

There was also a corresponding quantity of incoming commerce.

The timber along the banks is of excellent quality, and must, in a very short time, with facilities for reaching market, become a valuable article of commerce.

The work is situated within the collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$7,500 00	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$12,500 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		3,862 74
July 1, 1881, amount available		8,637 26
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,000 00

Q 11.

IMPROVEMENT OF BLACK RIVER, ARKANSAS.

During February last the charge of this work was transferred to me by Maj. W. H. H. Benyaurd. At that time operations in the field were suspended, and have not been resumed, up to the end of the fiscal year.

With the remaining balance of the appropriation of 1880 it is proposed to resume the work as soon as the stage of the water will admit of its being prosecuted with economy. It will be carried on on the same general plan as last season.

A boat will be hired for the removal of snags, and parties will work upon the improvement of the shoals.

From the wording of the item of the act of Congress approved March 3, 1881, which appropriates $6,000 for the improvement of the river, it

would seem that it is the design of Congress that the work under this appropriation should commence at Poplar Bluff—be pushed down stream. The item in question reads:

Improving Black River, Arkansas and Missouri, $6,000—to be applied from Poplar Bluff.

In furtherance of this design it is proposed to put a force of men on the river at Poplar Bluff, with suitable appliances to remove the principal obstructions to navigation, and let them work down stream as far as the amount of this appropriation will admit, which will probably be down to the point where the railroad crosses the river.

During the past season a slight change has been made in the character of the bridge at this place. A canal has been dug around one of the abutment piers, and over this a movable bridge has been placed. It admits of the passage of boats during high-water, but, as the canal is deep at ordinary low-water, it cannot be said to meet the objection, which the boating interests of this stream might raise to the bridge.

The country bordering on this section of the river within the last year has attracted considerable emigration. It is a fine cotton-raising country, and the better varieties of hard wood abound.

There is every reason to believe that with the increasing facilities for transportation that the removal of snags and obstruction to navigation will afford, the commerce of this river will be greatly increased. It is estimated that 2,000 bales of cotton were taken out of the Black River country during last season.

It is suggested that the work of improving this river could be prosecuted in a much more expeditious manner, with greater economy, and give greater satisfaction in every respect, were it possible to provide suitable appliances for carrying it on as it should be.

A strong, well built, light-draught boat, say 100 feet long, 25 feet beam, drawing 15 inches, with propelling power, should be provided. This should be equipped with suitable appliances, such as capstans, blocks, tackles, lines, axes, saws, &c., for removing snags and hauling out overhanging trees, that would be cut down. It should be rigged with a light dredging apparatus, a Long scraper, that could be removed when not required for immediate use.

There are many of the shoals along this river that are sometimes troublesome during low-water that might be greatly improved at very little expense, by low brush, or gravel, or rock dams, aided for a few hours, at the proper time, by dredging or the use of the scraper. The cost of such a boat and outfit I estimate to be almost $15,000. Its running expenses about $2,000 per month, working season seven months, repairs and care of property $1,000, making a total of $3,000. If this amount were appropriated at once, the improvement could be placed upon a good working basis, and subsequent small appropriations of from $6,000 to $10,000 yearly would suffice to put and keep the river in good navigable condition. Another great advantage in having such a boat as this is, that it be could used for improving the navigation of the smaller streams which empty into the Black River, for which small amounts are from time to time appropriated by Congress. After the most troublesome of the snags and obstructions are removed, one such boat as this would be sufficient, not only for the Black River and its tributaries, but the White also, from the mouth of the Black as far up as Buffalo Shoals.

The work is situated inthe collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Money statement.

July 1, 1880, amount available	$15,000 00	
Amount appropriated by act approved March 3, 1881	6,000 00	
		$21,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		9,895 99
July 1, 1881, amount available		11,104 01
Amount that can be profitably expended in fiscal year ending June 30, 1883.		30,000 00

Q 12.

IMPROVEMENT OF THE CURRENT RIVER, ARKANSAS AND MISSOURI.

A project for the improvement of this river was submitted by Maj. W. H. H. Benyaurd, Corps of Engineers, under date of December 1, 1880, and published in House Ex. Doc. No. 38, Forty-sixth Congress, third session.

The improvement proposed is by means of wing-dams made of brush and stone, or gravel, to concentrate the water over the shoal places, and to remove snags, logs, and overhanging trees.

The amount appropriated will be expended in furtherance of this object.

Work will be commenced at the mouth, and carried up stream as far as the funds will admit.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Memphis, Tenn.

Money statement.

Amount appropriated by act approved March 3, 1881	$2,000 00
July 1, 1881, amount available	2,000 00
Amount (estimated) required for completion of existing project	15,365 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	15,365 00

APPENDIX R.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVING HARBOR AND MISSISSIPPI RIVER AT ALTON—ICE-HARBOR AT SAINT LOUIS, MISSOURI—IMPROVING MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU, MISSOURI, AND MINTON POINT, ILLINOIS—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

REPORT OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., August 11, 1881.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1881, upon the works under my charge.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

R 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

At the date of my last annual report the sum of $33,825.85 was available for expenditure within these limits. A survey had been made of the river in the vicinity of Piasa Island with a view to preparing a plan for the improvement of that locality. The map was in course of preparation.

As soon as the map was completed it was made the subject of study and a project for the improvement was prepared, an outline of which is shown upon the adjoining sketch, Plate 1. It was forwarded to the department with my report of August 26, 1880. A Board of Engineers having been convened to report upon this project met in Saint Louis November 23, 1880.

The working season had already terminated on account of the unusually early advent of winter. Before the opening of the spring of 1881

the funds available were withdrawn and reappropriated for another purpose by the following proviso in the river and harbor act of March 3, 1881, viz:

* * * And the sums of money heretofore apppropriated for the improvement of the Mississippi between the Illinois and Missouri Rivers and unexpended are hereby reappropriated, and shall be applied to the improvement of the harbor and Mississippi River at Alton.

The sums referred to amount to $33,354.70. They will be accounted for hereafter in a separate annual report (see report upon harbor and Mississippi River at Alton).

The gauges at Grafton and Alton were read daily. The records are hereto appended, that of the former marked A, and that of the latter marked B.

No other work was done within these limits during the year, and none is contemplated under the general appropriation for the coming year.

CAHOKIA CHUTE.

The dam constructed across this chute in 1878 and repaired in 1879 has settled about 3 feet, leaving its crest about 6 feet above the low-water of 1863; otherwise it remains in good condition. It has fully accomplished the first result expected of it, viz, stopping the erosion of the Illinois shore. The second and more important result—the improvement of navigation by deepening the water in the chute west of Arsenal Island—is now becoming evident. Heavy shoaling has taken place during the recent high-water in the upper part of Cahokia Chute, which will shut off nearly all the water from that chute at medium and low stages. This must necessarily be followed by a marked improvement in the navigation of the other chute.

The height of the deposit already much exceeds the height of the dam. The work of the latter may be regarded as nearly finished. The present navigable channel will become better as the new river bank at the head of Cahokia Chute becomes higher.

The complete reclamation of this ground will be necessary to finally complete the improvement of the navigation, and this will probably require some supplemental works in the future. But the process of building up the new bank is going on now in so satisfactory a manner that it is thought best to do nothing further at this locality until the favorable impulse given by the dam shall have finally expended itself.

HORSETAIL BAR.

Operations at this locality were continued throughout the year whenever the elements would permit it. A long winter and a flood in the spring impeded the work and prevented its completion. Plate 2 shows the location of the works as they have now been constructed. Under the influence of the hurdles on the Illinois side, aided by changes caused by the dam across Cahokia Chute, several miles above, the channel early last autumn was shifted to the desired location on the Missouri side, as shown.

This change rendered it possible to suspend the construction of hurdles on the Illinois side sooner than had been anticipated. The influence of these works in causing deposits was felt all the way to Carroll's Island, 2 miles below, but so long as the efforts of the river were directed towards retaining its channel through them, it was necessary to re-enforce them by adding to their number. These efforts having been to a

great degree withdrawn, the works upon this side were suspended at secondary hurdle No. 29. The construction of hurdles on the Missouri side was begun in the spring, and was executed at a high stage of the river, the disadvantage of working in deep water being more than compensated for by the richer supply of building material carried by the river at that season.

The total length of primary hurdles—the name given to the longitudinal hurdles located upon the line of the new bank—constructed during the year was 9,500 feet, of which the cost, including engineering and contingencies, was $37,540.63, or $3.95 per linear foot. The total length of secondary hurdles, the name given to transverse lines, was 22,000 feet, of which the cost, including engineering and contingencies, was $78,537.90, or $3.57 per linear foot.

Of these totals 1,900 feet of primary hurdle and 11,630 feet of secondary hurdle were constructed upon new ground. The balance were consumed in reconstructing and repairing the work of this and of the previous year. This adds $8.53 per linear foot to the cost given last year of the dike built with floating curtains in prolongation of the training-wall, now called primary hurdle, making the total cost $24.28 per running foot. At the beginning of the year 31,000 linear feet of secondary hurdles had been constructed. The additions give 42,630 feet among which the repairs are to be distributed.

The process of building up the new banks has continued in a satisfactory manner. There have been occasional drawbacks when, a breach being made in the hurdles, the water would concentrate in a small channel and scour out some of the new deposit. Damages of this kind are to be expected at this stage of the work, and have been anticipated from the beginning. They are necessarily attendant upon a system in which brute strength is largely replaced by vigilance.

The breaches have been promptly and easily repaired. The final results for the year have been a substantial gain at nearly all points. Enormous deposits have been secured over the entire area between secondary hurdle No. 29 and Carroll's Island, as well as within the areas inclosed by the hurdles. Those on the Missouri side have been quite uniform in thickness, the top presenting a regular surface. Those on the Illinois side have in some cases taken the shape of the long conical bars peculiar to the Mississippi, and differ largely both in the actual thickness of deposit and in the height to which they extend. The height attained in some cases exceeded all expectation. The crest of one bar—the highest—made its appearance at a 31-foot stage, the fill at that place having been 23 feet since last July. Greater fill has occurred elsewhere, but at lower levels. The top of this bar was higher than the old bank; it has since shrunk to about the same height. The largest fill in the two years was secured in the deep hole just below the old dike 3, where, in the spring of 1879, there was a depth of 70 feet at a 12-foot stage. Dry bar has appeared at this place this year at a 22-foot stage, showing a fill of 80 feet. At some places, on the other hand, the fill has been but a few inches, though, as a general rule, such places have been under the influence of the works for but short periods. Plates 2 and 3 show the position of the deposits as they would appear at a 15-foot stage at the end and at the beginning of the year. That is the stage above which it is believed that the willow will grow, and at which further reclamation may be left to nature. The appearance of the bars at a lower stage is shown upon the sketches accompanying the report of Mr. Currie, assistant engineer.

The total quantity of material deposited within the area to be re-

claimed since the introduction of this system two years ago is over 13,000,000 cubic yards. This volume taken from the water-way of the river must be replaced by the excavation of a nearly equal volume, unless the area of cross-section and velocity of the stream are largely altered; an occurrence which is not the least probable. The beneficial effect upon the channel may be expected with perfect confidence.

The change in the location of the channel was a great gain, but was at first attended by a decrease in the depth below what was found the year before. The material composing the bars on the Missouri side consisted largely of coarse gravel, many of the pebbles measuring 3 inches in diameter. The excavation of this material was comparatively slow. Three principal reefs were developed.

On the 20th of August the depth upon the upper the reef—the most prominent one—was but 6 feet 6 inches, the Saint Louis gauge reading 11 feet 6 inches. This reef was raked with a large harrow dragged by the steamer Anita, and in a few days a depth of 1 foot additional was made.

The river then rose and the reefs were not again noticeable by navigators until October. On the 22d of October, the gauge reading 10 feet 2 inches, the depth was 6 feet on both the second and third reefs, the depth on the upper reef being about a foot greater. The steamer not being available, the harrow could not be used, and there being a less depth at some other points between Saint Louis and Cairo, the river was left to do its own excavation. This it did slowly but effectually. On the 3d of December, navigation being suspended on account of ice, with the gauge reading 4 feet, the depth on the three reefs was 4 feet 5 inches and 4 feet 6 inches, respectively.

On the 15th of December, with the gauge reading 5 feet 6 inches, the least channel depth on any reef was 7 feet; that is, there had been a total vertical cut since August of 6 feet 6 inches.

It being the habit of the river in wide places such as this to drop a portion of its sediment in its channel at high stages, it was expected that much of this excavation would have to be renewed during the coming year when the water falls. The channel depth has therefore been watched with considerable interest during the prolonged high-water of this spring.

The highest stage reached by the river was 33.65 feet, May 6. On the 9th of May, the stage having fallen to 29.9 feet, the least channel depth was 31 feet, showing a fill of less than 5 inches since December. On the 4th of June, the gauge reading 21 feet 4 inches, the depth was 21 feet, showing a fill of 1 foot 10 inches since December.

On the 9th of July, the gauge reading 21 feet 6 inches, the depth was 17 feet, showing a fill of 6 feet since December. Under the circumstances—the river remaining above a 20-foot stage for over four months, during two of which it was above 25 feet, and for two weeks above 30 feet—this fill is remarkably small.

The material thus deposited is light alluvion, the removal of which is very different from that of the heavy gravel excavated last autumn. It is expected that its removal will be accomplished so rapidly that the reefs will not again appear as obstructions, at least until a stage lower than that of last autumn is reached. The amount of this channel filling at high-water should diminish as the height of the new banks is increased.

The results of the year's work have been such as to increase the confidence felt in the efficiency of the system of construction here adopted.

The break-up of the ice this spring was the most violent of which there is any record. The flood which followed nearly equaled that of 1826 in height, and has never been exceeded more than four times, as far as known. A combination of two such occurrences in one year is a rarity that need not be expected more than once in half a century.

The total destruction of such portions of the works as had not completed their work of reclamation at the time of the break-up might have been anticipated. Instead of this, only a portion of the primary hurdle was carried away, and the injuries to the secondary hurdles were not excessive. Equal damage would have been inflicted upon any ordinary dike, however massively constructed. Although more extensive repairs than usual have been rendered necessary, largely increasing the cost, the works upon the whole have passed through the ordeal in a very satisfactory manner.

The experience of the year has led, however, to some modifications in the details of construction, which, though increasing the original cost, are thought to be in the interest of economy.

The floating curtains, supported at one side by buoys, and anchored on the other side to the bottom, of which several forms were illustrated in my last annual report, were originally introduced for application in very deep water, where piles could not be used to advantage. They served their purpose well, causing the depth to decrease so that piles could afterwards be used, and they may again be resorted to where great depths are to be contended with. But their employment cannot be advantageously extended to shoal-water, for the reason that it is not practicable to devise a thoroughly efficient buoy which shall at the same time be cheap. For all depths less than 35 feet the most efficient support for the brush obstacle is the pile, which acts in the double capacity of anchor and buoy.

For depths of 10 or 12 feet, sometimes increased to 15 feet, the brush is wattled directly upon the piles. In greater depths light hurdle-work mattresses are launched from floating ways, and secured in a vertical position against the piles.

The reasons for this difference are that in considerable depths the work of sinking the brush course by course is tedious and expensive, and the structure, when finished, has great buoyancy, tending to lift the piles.

The mattress launched against the piles is deprived of its buoyancy by the load of stone at one side which is used in sinking it. All piles are now braced, except in very shoal-water, 6 feet or less depth, the braces being introduced at intervals of 20 feet. The primary hurdle is provided with a footing of brush.

But little additional information relating to the plantation and growth of willows has been obtained. Cuttings of the larger diameters have more vitality than those of the smaller. A cutting should not be less than 1 inch in diameter. Nothing new concerning the lowest level at which the willow will grow has been procured, for the reason that the cuttings planted at the lower stages were either washed away or were covered with mud, and were lost. That level is believed to be not far from 15 feet above the low-water of 1863. A vigorous plant is not killed by being covered with mud and water for many weeks.

The works at Horsetail were under the supervision of Mr. D. M. Currie, assistant engineer. His report, to which attention is invited for details, is appended, marked E.

The expenditures were $116,078.53.

TWIN HOLLOW AND WIDOW BEARD'S.

A detailed hydrographic survey of the river, from the foot of Carroll's Island to the mouth of the Meramec, was made in October by my assistant, Mr. P. C. F. West. A plan for the improvement of this portion of the river, which includes the two notorious localities known as "Twin Hollow" and "Widow Beard's," was submitted with my report of January 28, 1881. An outline of it is shown upon the adjoining sketch, Plate 4. It has not been practicable to begin these works for want of the necessary plant. The large additions now being made to the latter, and the near completion of the works at Horsetail, will render it possible to push these new works with vigor during the present season.

PROTECTION OF BANK NEAR KASKASKIA.

Operations were resumed at this locality as soon as the water had fallen to a suitable stage, in the latter part of September. The work of former years was found breached in two places and more or less damaged in several others. The water, entering through the breaches in the form of eddies, had excavated curious bays of elliptical form. The diameter of one of these bays at the mouth was 180 feet, and the horizontal distance to which it had entered the bank was 135 feet. Orders were given to cut these bays off from the river by a line of fixed hurdles, built upon the line of the old bank, with a view to stopping the action of the water-augur and to causing deposits instead of excavation. Orders were given also to repair and strengthen the old work, after which it was to be extended down stream, using brush throughout instead of stone as before, for the high-water portion, and to begin the construction of a series of hurdle-dikes designed to change the direction of attack of the river.

Only a portion of this programme could be carried out. The hurdles crossing the mouth of one of the bays was completed and immediately gave beneficial results. Piles were driven for a similar construction at the other bay, but before the wattling could be completed a suspension of the work was made necessary by the advent of severely cold weather. To strengthen the old work two mattresses, measuring respectively 750 and 265 feet in length by about 80 feet in width, were sunk at the foot of the slope, outside the former protection. They overlapped each other by about 10 feet, thus giving a continuous protection to about 1,005 feet of bank.

To change the direction of attack of the river, a hurdle-dike was begun at the foot of Sainte Genevieve Island and built out to a total length of 1,140 feet, the outer 380 feet, however, not being completed. It acted in the manner expected of it, causing heavy deposits. On the 17th of November 4 inches of snow fell, and heavy ice formed in the river, putting a sudden stop to the work. This proved to be the permanent advent of winter, and operations were not resumed.

The works at Kaskaskia Bend were under the local supervision of Mr. Max E. Schmidt, assistant engineer. For a detailed description of them attention is invited to his report, extracts from which are appended, marked F.

During the severe winter which followed these operations, ice was formed in the river, varying from 1 to 2 feet in thickness. On the 10th of February the river rose 8 feet at Saint Louis, the most extraordinary rise in a single day on record. The enormous forces developed by this rise were disastrous to the work. Great fields of heavy ice thrown

against the outer portion of the hurdle-dike promptly destroyed that portion. The ice soon gorged in the channel south of Sainte Genevieve Island, about 4 miles above Kaskaskia Bend, forcing a large body of water down the north chute (see adjoining map, Plate 5). This chute was rapidly enlarged, and the dike was attacked in the rear. The ice gorging between the dike and the main Illinois shore, a deep channel was cut through the root of the dike between the latter and Sainte Genevieve Island. The water rapidly rose above the dike, and the latter, what is left of it, has been submerged ever since. It is probably almost wholly, if not wholly, destroyed.

The direct protection suffered severely also. Standing as it does nearly at right angles to the direction by which the stream approaches from above, it was exposed to such assaults as immense fields of ice 2 feet thick moving with a velocity of 7 or 8 miles an hour can give. A field of this character striking the shore seemed checked for a moment, but it was presently observed to be moving slowly up the bank, carrying a slice of the bank-protection and all with it. Many layers were piled up over each other upon top of the bank 30 feet above low-water. In this manner the part of the bank which was above the water surface was stripped of its protection. As this enables the river to cut in behind the mattresses at the foot of the slope, it is probable that most of this work also is destroyed. The prolonged high-water of this spring has rendered it impracticable to ascertain with accuracy what the condition of it is.

After the ice had done its work of destruction, the river rose steadily, with but few and slight oscillations, until in the latter part of April it went over its banks, and there was a flood.

The overflow, concentrating in a slight depression in the strip of land which separated the Kaskaskia River from the Mississippi, formed a considerable stream, which poured into the former river with a fall of about 6 feet. This overfall soon cut a deep hole in the soft, alluvial soil which constitutes the river's bed, and then began the process of cutting back towards the Mississippi, with which a junction was soon formed. This cut was opposite the lower end of the work, upon which further damage was inflicted. A deep excavation approaching the revetment from the rear totally destroyed it throughout the width of the cut. The cut is now about 500 feet wide and 30 feet deep when the Mississippi is at a 22-foot stage. There has been no enlargement as yet of the Kaskaskia River below the cut.

The total result of the ice and the flood, so far as it can now be ascertained, is that it will be necessary to begin the work again from the beginning.

In this state of affairs it is a pertinent question whether the work should be abandoned or should be begun anew. The accompanying map, Plate 5, shows the position of Kaskaskia Bend with reference to the Kaskaskia River, and to the Mississippi for some miles above and below. The position of the channel is represented by the broken black line. It shows where the efforts of the main stream are directed. Passing out of Sainte Genevieve Bend, the channel crosses over to the Illinois side and enters Kaskaskia Bend in a direction nearly at right angles to the Illinois shore. The Illinois bank thus constitutes an obstacle directly in the path of the river. The results are the same as those given by any other great obstacle, viz, a sharp change of direction, a heaping up of the waters, an increase of slope and velocity, with their attendant difficulties for ascending navigation. It is certainly not in the interest of navigation to make the present location of the channel permanent.

Curvature much more gentle than that here existing is required to give safe and easy navigation.

The necessity of this becomes still more apparent when the stability of the works is considered. The protection of the bank causes increased scour at its foot. It is evident that in the case of a curve which is unnaturally sharp, like this one, the additional scour must be unusually great. While this adds materially to the difficulty and cost of the work, it is believed to be practicable to hold the bank so long as water alone is to be resisted. But the movements of ice introduce new complications. For security against these, easy curvature is a necessity.

This cannot be obtained without a radical change in the location of the channel somewhere between Little Rock and Chester. To push the stream out of Kaskaskia Bend, filling up that bend and cutting off the point opposite, retaining the present position of the channel above and below, would accomplish this result with less injury to the inhabitants of the country than any other plan that occurs to me.

This would be an operation of great magnitude, and should be undertaken only with that understanding. Whether it could be finally accomplished at all is doubtful. The dike built last autumn at the foot of Sainte Genevieve Island was the first step towards that end, and there can be no assurance that similar works in the future will not meet a similar fate. In any event, the operation would be a long and costly one. To move bodily one of the largest rivers in the world from one place to another is no small undertaking. Navigation must necessarily be interfered with more or less during the execution of the work. Its cost cannot be estimated any more than that of a battle, which it would in many respects resemble. It would be several hundred thousand dollars at least.

The recent enlargement of the chute north of Sainte Genevieve Island —the map is constructed from a survey of last year and does not show the enlargement—and the cut into the Kaskaskia River suggest two ways by which the river may accomplish the necessary straightening in the next few years, if left to itself.

Other ways may be developed by the stream itself in a short time, for changes are rapid where the shape is so unnatural as in the present case.

In carrying out the programme of working down stream from Saint Louis in the general improvement of the river adopted for reasons given further on under the head of appropriation of March 3, 1881, it may be several years before this locality is reached. In the mean time the river will probably have worked itself into a better shape, but, whether that happens or not, the approach to any works which may be constructed here cannot be assured until after the improvement of the river above.

If the funds to be employed in this work are to come from the general appropriatlon for improving the navigation, as heretofore, there can be no question that the interests of navigation require that the work should now be abandoned.

It is true that the work was originally undertaken for the protection of land, and not for the improvement of navigation, and that this interest will suffer by its abandonment.

Experience has shown that the land which is immediately threatened cannot be protected without turning the river entirely away from it, or bringing it to it in a direction totally different from the one by which it now approaches. In either case other land must be destroyed, and in the latter case Sainte Genevieve would be deprived of navigable water. The river must be straightened. In whatever way that be accomplished, some one must suffer, fertile land must be destroyed, and

riparian owners, possibly town sites, must be deprived of navigable water. These injuries, if inflicted by the government, would be a just cause of complaint; if inflicted by the river without artificial aid, they are the act of a power from whose judgment there is no appeal. There are therefore objections also to undertaking at this time a rectification of the river for the purpose of protecting the local interests now endangered. Should it be thought proper, however, to do this, it is desirable that the money be provided separately from the general appropriation for improving the navigation, and that a large sum, not less than $100,000, be made available before the work is begun. It is to be remarked that this is the value, at $50 per acre, of 2,000 acres of land.

The expenditures were $12,326.34, leaving a balance of $5,697.25, which by the act of June 14, 1880, is required to be expended in this vicinity. As the employment of this sum alone would be simply to throw it away, it is desirable that it should be made available by new legislation for expenditure in the general improvement of the river.

DICKEY'S ISLAND TO MOUTH OF OHIO.

A few breaks in the revetment of the bank in rear of Cairo were found to have occurred, and the short working season of last autumn was devoted to their repair.

This work was under the general direction of Mr. Max E. Schmidt, assistant engineer, and under the immediate charge of Mr. W. S. Mitchell, assistant engineer. The report of Mr. Mitchell to Mr. Schmidt is appended, marked G, to which attention is invited for details.

Alternating floods from the Ohio and Mississippi rivers have prevented the prosecution of the work this spring. The planting of willows upon the upper portion of the slope remains to be done.

The expenditures were $6,517.23.

METHOD OF CARRYING ON THE WORK.

All work during the year has been done by hired labor and purchase of material in open market (except piles), and with satisfactory results. It is proposed to continue the system during the coming year, for the reason that the character of the work will not admit of the contract system without injury to the interests of the United States.

The reasons for this were fully set forth in my last annual report. (See Annual Report of Chief of Engineers for 1880, pages 1374, 1375.) These reasons still exist.

EQUIPMENT.

It had become evident before the close of the working season last autumn that a readjustment of the plant would be required to provide for the necessities of the works under the new system of construction. A considerable number of additional barges and pile-drivers would be required. Additional quarter-boats also were needed. It was thought best not to make any large additions until a new appropriation should be assured. The additions were at that time limited to one steam pile-driver, two quarter-boats, and three model barges. Advertisements for proposals for constructing the barges were inserted in the official advertising newspapers of Saint Louis, Cincinnati, Louisville, Ky., and Quincy, Ill., but only one proposal was received. This proposal being considered unduly high, it was rejected, and the barges were built by hired labor and purchase of material in open market. The pile-driver was constructed in the same manner.

The appropriation of March 3, 1881, providing for a large expansion of the work, corresponding additions to the plant have been necessary. For the expenditure of $600,000 per annum, it was estimated that forty-five barges and twenty pile-drivers would be required. Of these, eighteen barges and six pile-drivers were on hand.

The most serviceable and convenient kind of barge, and the most economical in towing, is the model barge; but its high price has rendered it desirable to resort for the present to some other means of transportation. Twenty-seven second-hand coal barges or barge flats were procured from the Ohio River. These are now being fitted with capstans and rough decks, and otherwise repaired.

They are expected to last two or three years, at the end of which time they can be replaced by similar vessels or by model barges, as may be thought best.

To avoid the delay incidental to building by contract, the construction of fourteen new steam pile-drivers was begun in March by hired labor.

Progress upon them has been much impeded by the failure of lumber merchants to deliver material. At the end of the year five of them were completed and good progress was making upon the others. A detailed drawing of one of these machines was forwarded to the department with my letter of April 25, 1881.

With a view to keeping down to the lowest limit expenditures upon new plant, no additions have been made to the quarter-boats. Portable buildings, as kitchens, laborers' quarters, and offices, are in course of construction. These can be set up on shore and moved whenever it becomes necessary. They are less expensive than floating quarters, and, while not so convenient, can be utilized at the more extensive works, while the quarter-boats now on hand are employed at the places where the force is engaged for shorter periods. The principal objection to buildings on shore is the possible difficulty of procuring permission from the owners of land to put them up. This difficulty may vanish in practice, in view of the fact that they can be removed at a moment's notice.

Four buildings, each providing an office and quarters for an assistant engineer; four buildings, each providing kitchen, store-rooms, and mess-room for seventy-two laborers, and two buildings, each providing sleeping-quarters for seventy-two men, have been constructed.

The expenditures upon this plant were $75,446.04.

As this extensive equipment cannot properly be charged to the cost of the work in any one year, a special record is kept, in which it is treated as so much unexpended appropriation.

Each work is charged for the use and repairs of such equipment as may be employed upon it. The amount proper to be charged is obtained from the first cost and average life of the vessel. Small repairs are charged to the work at the time when they are made. Extensive repairs, which increase the value of the vessel, are added to the balance remaining of the first cost, and treated like that. In this way an accurate statement of the actual cost of each work, including all contingencies, is procured.

It is in this way that the costs given in this report are ascertained. The present valuation of the property remaining to be distributed in the future is given in the last column of the following table, in which are given, also, its valuation at the beginning of the year, the sums which have been expended upon it, and its estimated deterioriation during the year.

Class of property.	Balance, July 1, 1880.	Dr.	Cr.	Balance, June 30, 1881.
Steamer A. A. Humphreys	$20,955 64	$1,446 08	$3,487 55	$18,914 17
Steamer Anita	5,257 98	690 85	1,096 86	4,851 97
Launch Hornet	153 21	170 09	217 59	105 71
Tug Mignon	4,212 72	106 31	241 31	4,077 72
Barges	29,569 24	55,741 03	13,990 10	71,320 17
Pile drivers	2,370 72	35,512 63	4,706 80	33,176 55
Quarters, shops, &c	11,017 82	9,810 43	5,383 20	15,445 05
Skiffs, flats, &c	591 24	1,879 74	706 00	1,764 98
Tools and appliances	2,720 01	3,251 81	1,560 00	4,411 82
Office furniture	224 05	283 65	65 75	441 95
Surveying instruments, &c	1,056 70	108 75	50 50	1,114 95
Totals	78,129 33	109,001 37	31,505 66	155,625 04

SURVEYS.

The general topographical survey, which at the beginning of the year had been carried down as far as Kaskaskia Bend, was resumed in the latter part of July. It was learned a few days after the party had taken the field that the Mississippi River Commission were about to run a line of precise levels over the same ground. Leveling operations were at once suspended and the work was limited to tracing the shore lines and topography of the banks. These levels terminate at the mouth of the river Aux Vases. The topography having been extended to the foot of Cousin Will's Island, it was there suspended in the latter part of August until the completion of more pressing work, which required the services of the assistants and the plant. It was resumed in the latter part of October, and was extended by the 20th of November to Allen's Landing, where it was stopped for the season by severe cold weather. A pressure of other work has prevented its continuation this spring, but it is expected that it will be resumed at an early day.

The length of river surveyed was 21 miles. The work was executed with the plane-table upon a scale of $\frac{1}{10,000}$, using the old triangulation as a ground work. It was under the direction of Mr. P. C. F. West, assistant engineer.

Besides the special survey from Carroll's Island to the mouth of the Meramec, already alluded to, there has been undertaken this spring, under the appropriation of March 3, 1881, with a view to preparing plans of improvement and estimates of cost, a detailed hydrographic survey from the Meramec to White Sand Depot, omitting a stretch of 4 miles near Brickey's Mill.

Two parties have been employed under the respective direction at first of Mr. P. C. F. West and Mr. W. S. Mitchell, assistant engineers.

Mr. West having tendered his resignation, his party was placed in charge of Mr. J. O. Holman, assistant engineer. The field work is completed to Rush Towhead, 19 miles from the Meramec, where it has been suspended, as it is believed to be far enough in advance of the improvement to provide for present necessities. It is desirable in preparing plans to have the maps as recent as practicable. The survey will be resumed whenever the advance of the improvement renders it necessary.

The hydrographic maps made for the purpose of preparing plans of improvement have been constructed with the plane table, the scale being $\frac{1}{5000}$. A hydrographic survey with this instrument being something of a novelty, Mr. West has, at my request, prepared a description of the method as devised by him, which is appended, marked H. The method has proved to be well adapted to the conditions of our work, in which

the sheets of water are long, comparatively narrow, and tolerably straight. It is rapid, accurate, and economical, its cost being less than 75 per cent. of a transit survey executed to the same degree detailed.

The expenditures were for general topographical survey, 21 miles, $1,906.62, and for detailed hydrographic surveys, 25½ miles, $5,605.18.

The gauge at Gray's Point was read daily throughout the year.

A copy of the record is appended, marked C.

NAVIGABLE DEPTH BETWEEN SAINT LOUIS AND CAIRO.

The changeable character of the bars and shoals in this portion of the Mississippi River often making the navigation good at some place where in the previous year it was bad, and *vice versa*, render it desirable that a record should be kept of the depths found at different seasons at localities where obstructions are most often found.

Without a record of this kind the engineer often has tradition alone to guide him in deciding whether any given portion of the river shall be the subject of improvement or not. It will often happen that his hydrographic survey will show a good channel at a place where the year before it was very bad, and where the year after it may without improvement be the same.

It is evidently impracticable, on account of the cost, to provide special observers who shall watch the appearance and disappearance of every bar over a long stretch of river.

The Association of Saint Louis and New Orleans pilots have furnished me the means of compiling a record which will answer the purpose reasonably well, and will, I think, constitute a valuable contribution to the history of this portion of the river. Whenever a member of this association has passed over the river between Saint Louis and Cairo he immediately makes a written report to the association, noting any change in the location of the channel and the depths found upon the bars. These reports, after serving their purpose with the association, have been transferred to me.

The tabular statement appended, and marked D, gives the depths thus reported for nearly every day from the 1st of August to the close of navigation in November. The depths were measured with the ordinary sounding lead of the boat, except where they were less than 6′, when a rod was usually employed, giving a more accurate measurement.

At high stages the boats frequently did not follow the deepest water, the reports were much less frequent, and the measurements themselves were much less accurate. The data procured in this way, at such times, would be misleading rather than instructive. The statement, therefore, does not include the reports made during the spring months.

The record, as it stands, gives a fair picture of the condition of the river during the low-water season, as it appeared to those engaged in navigating it. In many cases a less depth is reported by one person than was found by another on the same day, the difference being due to the difficulty of following out the deepest channel in a wide expanse of water. Strict accuracy cannot be claimed for any one measurement, but if several days be taken together, the gauge record also being considered, a close approximation to the depth existing throughout the season upon every bar will be found.

The river did not reach a very low stage this year, and the navigation upon the whole was better than it has sometimes been in former years. The least depth reported was that in the crossing from Wahoo to Cape Girardeau, which was 5′. The phenomenon of a falling river, attended

by a maintained or increased depth upon the bars, is illustrated in a number of cases.

Some well known localities do not appear in the list, because the navigation there has been good this year, and no soundings were taken.

An effort was made to procure similar reports for the portion of the river above Saint Louis, but it was not successful.

STANDARD LOW-WATER.

The lowest water recorded at Saint Louis is the low-water of 1863. That level constitutes the zero of the gauge at this place, and it is usual in speaking of low-water, without other qualification, to refer to the lowest water, or the zero of the gauge. The term low-water when applied to a plane of reference from which are to be measured the channel depths to be procured or maintained by the works of improvement, has never been defined.

Such a level must be determined by considerations different from those by which the zero of a gauge is fixed. The latter may be anywhere, it being convenient to place it so low that the reading shall always have the plus sign. Low-water of 1863 seems a very proper level for that purpose. But to take that as the level below which a depth of 8′ is to be procured is to require more of the works than is necessary.

The season of lowest water always occurs in the winter, when the sources of supply in the North are closed by frost. At this season the river is subjected to ice gorges, which, while putting a stop to navigation, dam back the water and cause the gauges to give indications which are entirely abnormal. The low-water of 1863 occurred on the 21st of December, and there is every indication, in the record before and after, that it was occasioned by an ice gorge. For the purposes of navigation it is a matter of indifference how little a depth there may be in the channel when the river is frozen over. The level from which it will be proper to measure depths should be the lowest one to which the river is likely to fall during the navigable season. This can only be determined by a comparison of the gauge record with the dates upon which navigation has been suspended on account of ice for a considerable number of years.

The gauge record kept at Saint Louis up to October 16, 1871, gives simply an approximation to the different stages of the river. I am informed by Mr. Jacob Leopold, who kept the record, that there was no gauge.

The level of the water surface was ascertained by leveling down from the city directrix whenever the city surveyor happened to be on the spot, the stages for the days between such occasions being computed from the estimated rise or fall of the river since the previous leveling. While it is probable that the low-water of 1863 received special attention as being an extraordinary occurrence, it is evident that as a general rule the stages given in that record are not to be relied upon for the purpose of the present investigation. In October, 1871, a regular gauge was established by the Signal Service, and was read for the first time on the 16th of that month, and in 1873 the present permanent gauge was established by Major Merrill. A reliable gauge record exists, then, for only about 10 years. This is perhaps not a sufficient length of time to fix with accuracy a standard low-water, but as such a standard is constantly needed for the purpose of studying hydrographic maps, it seems proper to select one which shall be as near an approximation to the truth as present information will permit.

I have procured from the records of the Saint Louis and Vicksburg Anchor Line Steamboat Company, and of the Merchants' Exchange of Saint Louis, the dates upon which navigation has been suspended on account of ice between Saint Louis and Cairo during the time covered by the reliable gauge record.

A convenient way to discuss these records is to assume some level as an approximate standard low-water and to compare this with them. A stage of 4′ above the low-water of 1863 is assumed. The following table shows the year and the season when the river fell below this level, with its condition as regards ice at such times, the number of days during which it remained below the assumed standard when not closed by ice, and the lowest level which it reached:

Year.	Dates below 4-foot stage.	Number of days below 4-foot stage.	Dates when frozen.	Number of days frozen.	Number of days below 4-foot stage when not frozen.	Extreme distance below 4-foot stage.
						Feet.
1871	October 16 to November 11, November 29 to December 5, December 20 to December 26.	41	November 29 to December 5, December 20 to December 26.	14	27	1.47
1872	January 15 to January 17, January 19 to January 30, November 24 to December 26.	48	January 24 to January 30, November 29 to December 4, December 12 to December 26.	28	20	21
1873	November 30 to December 2...	3	.....	0	3	0.14
1874	December 30 and 31.....	2	December 30 and 31	2	0	
1875	January 1 to January 4, January 6 and 7.	6	January 1 to January 4, January 6 and 7.	6	0	
1876	None.....	.....	.....		0	
1877	None.....	.....	.....		0	
1878	None.....	.....	.....		0	
1879	December 25 and 26.....	2	December 25 and 26	2	0	
1880	November 28 to December 2...	5	November 28 to December 2..	5	0	

It appears from this that during the last seven years, 1874 to 1880, the river has not fallen below the assumed standard at all, except when closed to navigation by ice, and in the preceding year, 1873, it was below it but three days, and then only fourteen-hundredths of a foot. If the record of the last eight years be alone considered, there can be no doubt that the assumed standard is quite low enough.

In 1872 the river was below the assumed standard for twenty days when not actually closed by ice. Seven of these days, December 5 to December 11, being preceded and followed by a frozen river, were not available for any heavy movement of freight.

During the eight days January 15 to 17 and January 19 to 23, the latter followed by a closure, the river must have been threatening and expected to close (it had been closed during the preceding month, December, 1871), so that the same remarks as to the movement of freight are applicable to these days. There is some doubt as to whether they are applicable to the five days remaining, November 24 to 28. The season was unusually early for a suspension of navigation, but at the same time the river rarely closes without several days' warning. During these five days the water surface was 0.13, 0.30, 0.50, 0.55, and 0.7 inch below the assumed standard, and the following day it was frozen. As freezing

over is nearly always preceded by heavy floating ice, which is itself a serious obstruction to navigation, it is thought that there is nothing in the record of 1872 to cast serious doubt upon the correctness of the assumed standard.

In 1871, however, twenty-seven days are found during the navigable season, October 16 to November 11, when the water surface was lower than this, and it is uncertain how many such days occurred previously to October 16. While this does cast a doubt upon the correctness of the standard, it is not conclusive against it. The record certainly does not show that the river is *likely* to fall below the assumed standard. So far as it extends it shows the reverse.

Ten years further observations will probably be required to settle this question with accuracy. For present purposes it is believed that a stage which marks 4 inches on the Saint Louis gauge may fairly be taken as a standard low-water. Works which will procure a channel depth of 8 feet at that stage may be regarded as providing for the present needs of commerce.

LOW-WATER DISCHARGE.

There has always been great difficulty in measuring the volume of discharge of the river at a very low stage, on account of the ice which is usually found at the season when the lowest water occurs. The value assigned to that quantity has been obtained by estimating from measurements taken at stages much higher than the low-water stage. From the nature of the stream this method gives only an approximation, which cannot be regarded as very close. On December last the river in front of Saint Louis became nearly free of ice, at a stage 4.45 feet above low-water of 1863, or 0.45 foot above what may, for the present, be considered standard low-water. A favorable opportunity being thus offered for measuring the discharge, at a stage much lower than any at which it had been previously measured, advantage was taken of it and the river was gauged. The discharge was found to be 47,800 cubic feet per second, at the stage, 4.45 feet, from which the discharge at a 4-foot stage, or standard low-water, is computed to be 47,000 cubic feet per second.

This work was done by my assistant, Mr. Wm. Popp, whose report, giving in detail the methods employed in taking the observations and making the computations, was forwarded to the department with my letter of January 6, 1881.

APPROPRIATION OF MARCH 3, 1881.

The allotments made from the appropriation of March 3, 1881, amounting to $600,000, were for—

Twin Hollow and Widow Beard's	$115,000 00
Cape Girardeau, Missouri, and Minton Point, Illinois	45,000 00
Repairs and contingencies	10,000 00
New plant	75,000 00
Surveys	5,400 00
Total	250,400 00

Which leaves a balance of $349,600 available for beginning new works.

The allotment to Cape Girardeau was made on account of the special appropriation for that place which makes it necessary to keep there a force of assistants with a steamboat and other plant. The work is of a kind that requires constant watching. It is not safe to send a force there, expend the appropriation in a prompt and economical manner, and then disband or move elsewhere. Breaches are likely to occur in the brush obstacles, and these should be promptly repaired to prevent

serious damage. The special appropriation is not large enough to keep any considerable force at work during the entire season. At the same time, operations upon a small scale render the plant, particularly the steamboat, a very serious drain upon the appropriation. The works have a double object, viz, to provide convenient access to the Cape Girardeau landing, and to improve the general navigation of the river for several miles above. In their latter capacity they were thought to be a proper object of expenditure of the general fund, and it was accordingly decided to carry them on under both the special and general appropriations.

The distribution of the remaining $349,600, or rather the survey undertaken with a view to preparing plans for its distribution, has been determined by the following considerations:

1st. The primary object of the improvement being to procure cheap through transportation for freight, the funds should be applied exclusively to such works as tend to deepen and maintain the present channel.

2d. The greatest benefit to the greatest number will be obtained by applying them below Saint Louis.

Vessels engaged in the trade above Saint Louis are, as a general rule, obliged to adapt their draught to what may be found in the Mississippi above the mouth of the Illinois, or in the Illinois or Missouri rivers. The channel depth between Saint Louis and the mouth of the Illinois is believed to compare favorably with that to be found in those rivers. At all events, the portion of the river lying between Saint Louis and Cairo is the one which carries the greatest amount of commerce, and is the part in which the deepening of the channel is most urgently required.

3d. The improvement should as far as practicable be continuous. The greatest economy in the use of plant and in administration can thus be obtained. The improvement of one section facilitates the improvement of the next. It is better, in the interest of navigation, that such obstacles as remain should be confined to one portion of the river than be distributed over all portions of it.

4th. It will not, as a general rule, be advisable to allot to any one locality funds sufficient to entirely complete its improvement with this appropriation. In nearly all cases two classes of works are required, viz, those to build up new banks, and those to preserve old banks, or revetments. The latter class are preservative, and do not usually afford relief from the obstructions now existing, there being an exception in the case of banks caving with great rapidity. The time required for their completion is dependent only upon the amount of means applied to them. Works of the first class are those which afford immediate relief to navigation. They form the first step in a process which will occupy many years, the number of which is uncertain; for the improvement can not be regarded as complete until the new banks have reached the height of the old ones. The first steps in this process are very rapid, and the last steps very slow. While the navigation will grow better and better each year until the process is completed, the greatest amount of benefit will be received at first. It would seem proper to obtain this immediate relief at as many places as possible, and afterwards, while the more tedious process of adding to the height of the reclaimed land is going on, to proceed with the revetment of the old banks. In all cases, therefore, when the rate of erosion does not exceed 20 feet a year, the revetments may for the present be postponed. More extended surveys are therefore required than would otherwise be necessary.

5th. It is desirable to work down stream from Saint Louis. In this

manner the channel is fixed as we progress, and its approach to the works below being known they can be properly designed to receive it. To work up stream leaves the channel free to approach the prepared bed in the manner designed for it, or to approach in some entirely different and unforeseen way.

Moreover, the channel depth obtained at first in the upper portion of the improved river is to a certain degree fictitious. It will be partially due to the pounding back of the water by the bars below, and as these are cleared out there will be a tendency to diminish the depth. At the same time the process of building up the new banks in the upper portion will be going on, and this tends to increase the depth. The removal of each bar, while tending to decrease the depth above, will increase that below. If the improvement be prosecuted from the lower end the first results will perhaps be locally greater than if it begin at the upper end, but they will be partially at the expense of the unimproved portion. In short, improvements below injure all above, while improvements above help all below. The most regular and uniform improvement of the entire section can therefore be obtained by working down stream.

Projects having been approved for the improvement of the river from Saint Louis to the mouth of the Meramec, 20 miles below the Saint Louis Bridge, the detailed hydrographic survey already alluded to was undertaken from that place to White Sand Depot, 51 miles below the bridge.

The foregoing assumes that the obstacles which exist or are likely to be formed between the mouth of the Meramec and Cairo do not vary largely among themselves in magnitude.

That this is the case is shown by the following table, in which are given the approximate distances below the Saint Louis Bridge of the localities where obstructions have been found in the last two years, with the least channel depth reported in 1879 and 1880:

Distance below Saint Louis bridge.	Interval.	Locality.	1879.		1880.		Remarks.
			Least depth in channel.	Stage above low-water of 1863.	Least depth in channel.	Stage above low-water of 1863.	
Miles.	*Miles.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
20½		Jim Smith's	6	8.75	7	8.10	
	4½						
25		Foster's Island	8	8.75	5½	8.10	
	2½						
27½		Herculaneum	5	8.10	6	8.10	
	3½						
31		Cornish Island	5½	.....	6½	10.58	
	2						
33		Selina	.....	.....	6	8.10	
	1½						
34½		Forest Home	7	8.75	8	8.17	
	1½						
36		Perry's Towhead	8	8.20	7	8.17	
	12						Brickey's Mills.
48		Fort Chartres	7	8.75	6½	8.42	
	7						Turkey Island.
55		Ste. Genevieve Island	5	8.55	7½	8.10	
	9						
64		Kaskaskia	4	.....	6	8.17	
	5						
69		Ste. Mary	.....	.....	6	8.17	
	10½						Cheshire.
79½		Ste. Mary's River	5	8.10	6	8.17	
	4½						

Distance below Saint Louis bridge.	Interval.	Locality.	1879.		1880.		Remarks.
			Least depth in channel.	Stage above low-water of 1863.	Least depth in channel.	Stage above low-water of 1863.	
Miles.	*Miles.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
84		Liberty Island	5½	8.60	6	8.17	
	5½						
89½		Jones's Point	4⅝	8.75	5½	8.10	
	9						
98½		Hat Island	5	8.45	8	8.75	
	16						Grand Tower Gorge.
114½		Crawford	5	8.10	6	8.17	
	8						
122½		Moccasin Spring	5½	8.10	5¼	8.25	
	5						
127½		Swift Shore Towhead	5½	8.20	6	8.10	
	2½						
130		Kinney Point	5½	8.55	8	8.17	
	3½						
133½		Devil's Islet (foot)	6	8.10	6	8.17	
	3½						
137		Cape Girardeau	5½	8.10	5	8.17	
	15						Commerce Gorge or Grand Chain.
152		Jacket Pattern	5	8.10	6	8.17	
	3						
155		Goose Island	5½	.....	6	.....	
	14						
169		Thompson's	6	.....	9	.....	
	3						
172		Scudder Towhead	6	.....	10½	.....	
	6						
178		Pond Lily	6	.....	5½	.....	
	2						
180		Eliza Point	8	.....	5	.....	

Of the twenty-seven localities enumerated nine are found within the limits to be covered by the detailed surveys. While some of these have been during the last two years of less magnitude than some of those below, the difference is not great enough to warrant a departure from the systematic method proposed; moreover, there is no certainty that the obstacles above will not be increased next year, while those below are diminished.

ESTIMATE FOR YEAR ENDING JUNE 30, 1883.

The amount given as that which can be profitably expended during the year ending June 30, 1883, is $1,000,000. It is proposed to employ it in continuing the works to be begun this year, and in extending the improvement in accordance with the programme just described.

The plan is to make the improvement continuous, working down stream from Saint Louis, by reclaiming land and building up new banks, thus reducing the width of the river to the uniform width of about 2,500 feet. It is proposed by this means to secure a minimum depth of 8 feet. The depth is now liable to become as little as 4 feet in some places and less than 8 feet in every place where the width is greater than 2,500 feet.

Caving banks are to be protected.

This general statement of the proposed application of the appropriation is as specific as the nature of the case will admit of. The changeable character of the river renders it impracticable to give in advance the exact localities where works will be required.

The work is located in the collection district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$283,338 57	
Amount appropriated by act approved March 3, 1881	600,000 00	
		$883,338 57
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	231,395 81	
Amount re-appropriated by act of March 3, 1881, to be applied to harbor and Mississippi River at Alton	33,354 70	
July 1, 1881, outstanding liabilities	1,778 71	
		266,529 22
July 1, 1881, amount available		616,809 35
Amount (estimated) required for completion of existing project		5,539,420 32
Amount that can be profitably expended in fiscal year ending June 30, 1883		1,000,000 00

NOTE.—Amount re-appropriated by act of March 3, 1881, to be applied to harbor and Mississippi River at Alton, and amounts expended at Kaskaskia Bend are added to estimate of last year.

Construction Account.

Name of work.	Exp'ded prior July 1, 1880.	Expended during fiscal year ending June 30, 1881.	Total to June 30, 1881.
Piasa Island Dam	$32,333 30		$32,333 30
Alton Dam	33,623 92		33,623 92
Sawyer's Bend protection	96,803 63		96,803 63
Venice dikes	36,341 85		36,341 85
Arsenal Island protection	9,673 85		9,673 85
Closing Cahokia Chute	116,088 60		116,088 60
Horsetail Bar, dike 1	40,549 53		40,549 53
Horsetail Bar, dike 2	23,600 26		23,600 26
Horsetail Bar, dike 3	82,692 54		82,692 54
Horsetail Bar, dike 4	41,290 11		41,290 11
Horsetail Bar, dike 5	36,933 87		36,933 87
Horsetail Bar, training wall	80,627 03		80,627 03
Horsetail Bar, primary hurdles, Horsetail Bar, secondary hurdles,	89,757 57	$116,078 53	205,836 10
Fort Chartres Dam	36,812 86		36,812 86
Turkey Island	24,463 85		24,463 85
Kaskaskia protection	54,139 28	12,326 34	66,465 62
Liberty Island dam	5,053 91		5,053 91
Liberty Island protection	45,129 40		45,129 40
Devil's Island, dike 1	65,871 17		65,871 17
Devil's Island, dam 1	49,848 58		49,848 58
Devil's Island, dam 2	16,678 30		16,678 30
Cairo Protection	113,351 43	6,517 23	119,868 66
Total	1,131,664 84	134,922 10	1,266,586 94

Property and material account.

Class of property.	Balance July 1, 1880.	Total debts.	Total credits.	Balance June 30, 1881.
Steamer A. A. Humphrey and expenses	$14,210 64	$25,628 26	$20,924 13	$18,914 77
Steamer Anita and expenses	3,595 48	6,691 54	5,435 04	4,851 97
Launch Hornet and expenses	105 71	1,300 49	1,300 49	105 71
Tug Mignon and expenses	4,212 72	386 63	521 63	4,077 72
Barges	20,069 24	65,241 03	13,990 10	71,320 17
Pile drivers	1,610 72	36,272 63	4,706 80	33,176 55
Quarters, shops, &c	7,495 37	13,332 88	5,383 20	15,445 05
Skiffs, flats, &c	401 24	2,069 74	706 00	1,764 98
Tools and appliances	1,865 01	4,106 81	1,560 00	4,411 82
Office furniture	224 05	283 65	65 75	441 95
Surveying instruments, &c	1,056 70	108 75	50 50	1,114 95
Material, stone, Little Rock	1,581 99			1,581 99
Material, stone, Saint Louis		6,229 57	6,229 57	
Material, piles, Saint Louis	915 50	42,768 98	42,562 80	1,121 68
Material, brush, Saint Louis		19,931 30	19,714 10	217 20
Material, miscellaneous		7,606 84	4,553 14	3,053 70
General expenses of property	23,282 45		23,282 45	
Total	80,626 82	231,959 10	150,985 71	161 600 21

Abstract of proposals for furnishing piles for Horsetail Bar, Mississippi River, received in response to advertisements dated August 9, 1880, and opened August 23, 1880, by Capt. O. H. Ernst, Corps of Engineers.

Number of proposal.	Names of bidders.	Residence.	Delivered at Horsetail Bar. Cottonwood piles, per pile. 500 20 feet long.	500 23 feet long.	500 28 feet long.	1,500 30 feet long.	500 32 feet long.	500 34 feet long.	Amount.
*1	John Cleary	Chester, Ill	.....	.....	.....	.....	.....	.....	.....
†2	W. Hughes	....do	.....	.....	.....	.....	.....	.....	.....
*3	John W. Reno	....do	.....	.....	.....	.....	.....	.....	.....
4	William K. Patrick	Saint Louis, Mo	.....	.....	.....	.....	.....	.....	.....
5	William McIntosh	Clarksville, Mo	.....	.....	.....	.....	.....	.....	.....
6	Martin Michael	Saint Louis, Mo	$2 00	$2 40	$2 90	$3 40	$4 00	$4 50	$13,000
7	August Eyermann	....do	3 10	3 10	3 10	3 10	3 10	3 10	12,400

Number of proposal.	Names of bidders.	Delivered at Horsetail Bar. Hardword piles, per pile. 300 40 feet long.	300 44 feet long.	300 48 feet long.	200 52 feet long.	Amount.	Delivered on government barges at landings within 100 miles of Saint Louis. Cottonwood piles, per pile. 500 20 feet long.	500 24 feet long.	500 28 feet long.	1500 30 feet long.	500 32 feet long.	500 34 feet long.	Amount.
*1	John Cleary	.....	.....	.....	.....	.....	$1 00	$1 20	$1 40	$1 50	$1 70	$1 90	$5,850
†2	W. Hughes	.....	.....	.....	.....	.....	1 00	1 20	1 45	1 60	2 00	2 20	6,325
*3	John W. Reno	.....	.....	.....	.....	.....	1 20	1 44	1 68	1 80	1 92	2 04	6,840
4	William K. Patrick	.....	.....	.....	.....	.....	1 15	1 35	1 60	1 75	1 90	2 00	6,625
5	William McIntosh	.....	.....	.....	.....	.....	3 00	3 60	4 20	4 50	4 80	5 10	17,100
6	Martin Michael	$5 00	$5 60	$6 20	$7 00	$6,440	.....	.....	.....	.....	.....	.....	.....
7	August Eyermann	6 50	6 50	6 50	6 50	7,150	.....	.....	.....	.....	.....	.....	.....

Number of proposal.	Names of bidders.	Delivered on government barges at landings within 100 miles of Saint Louis. Hardwood piles, per pile. 300 40 feet long.	300 44 feet long.	300 48 feet long.	200 52 feet long.	Amount.	Location of landing.
*1	John Cleary	$2 60	$2 85	$3 12	$3 38	$3,247	Chester, Ill., and Ste. Genevieve, Mo.
†2	W. Hughes	2 50	2 80	3 25	3 65	3,295	Not stated.
*3	John W. Reno	2 80	3 52	3 84	5 20	4,088	Clearyville and Chester, Ill., and Ste. Genevieve, Mo.
4	William K. Patrick	3 20	3 96	4 80	5 72	4,732	Liberty Island, Mississippi River, Missouri shore.
5	William McIntosh	7 20	7 92	8 64	9 36	9,000	Clarksville, Mo., and above mouth of the Missouri River.
6	Martin Michael	.....	.....	.....	.....	.....	
7	August Eyermann	.....	.....	.....	.....	.....	

* Not in duplicate. † Presumed to be from W. Hughes. Bid not signed nor bond executed.

Abstract of proposal for building and delivering at Saint Louis, Mo., three barges for improvement of the Mississippi River, received in response to advertisement dated September 7, and opened October 2, 1880, by Capt. O. H. Ernst, Corps of Engineers.

Number of proposal.	Name of bidder.	Residence.	Price for three barges.
1	William Jones	New Albany, Ind	$15,400

A *Record of gauge at Grafton, Ill., for the fiscal year ending June* 30, 1881.

[Height of water above a plane 200 feet below the Saint Louis City directrix.]

Day.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	208.81	199.36	195.64	197.64	194.70	195.50	195.45	194.60	199.50	206.60	213.88	204.55
2	09.21	99.06	95.75	98.20	94.66	95.75	95.60	94.68	200.10	06.95	14.02	04.10
3	09.66	98.76	95.80	98.72	94.60	95.44	95.74	94.50	199.75	07.10	14.05	03.82
4	09.76	98.46	96.00	98.85	94.60	95.40	95.74	94.52	99.30	07.44	14.18	03.50
5	09.86	98.16	96.15	98.60	94.68	95.45	95.50	94.60	99.52	07.64	14.25	03.20
6	10.21	97.86	96.42	98.30	94.70	95.80	95.40	95.06	99.80	07.65	14.10	03.50
7	10.31	97.68	96.65	97.95	94.62	95.95	95.32	95.55	200.05	07.88	13.70	02.75
8	10.41	97.52	96.90	97.60	94.62	95.72	95.20	95.80	200.00	08.50	12.00	02.55
9	10.41	97.46	97.15	97.30	94.65	95.20	95.16	97.35	199.95	08.90	11.95	02.74
10	10.31	97.31	97.32	97.00	94.75	95.35	94.90	99.55	200.00	09.10	10.80	03.02
11	10.11	97.12	97.30	96.74	94.80	95.75	94.80	200.80	00.20	09.40	10.02	03.32
12	09.76	96.60	97.06	96.50	94.85	95.90	94.70	01.15	01.52	09.65	09.20	03.65
13	09.56	96.34	96.85	96.15	94.80	96.02	94.70	01.20	02.60	09.85	08.92	04.05
14	09.21	96.10	96.60	95.94	94.80	96.30	94.70	00.75	03.55	09.95	08.75	04.40
15	08.71	95.90	96.25	95.70	94.82	96.30	94.68	00.40	03.50	10.00	08.50	04.65
16	07.76	95.68	96.00	95.45	95.05	96.42	94.65	199.90	03.70	10.00	08.50	05.00
17	07.36	95.45	95.70	95.20	95.10	96.30	94.62	99.50	04.05	10.00	08.52	05.35
18	06.46	95.30	95.45	94.86	95.20	96.28	94.60	99.30	04.04	09.90	08.70	05.70
19	05.61	95.25	95.35	94.72	95.02	95.78	94.70	99.02	04.20	09.80	08.85	06.05
20	04.81	95.20	95.25	94.76	94.75	95.08	94.74	98.85	04.40	09.85	09.00	06.35
21	04.02	95.00	94.95	94.85	94.60	94.75	94.74	98.80	04.04	10.10	09.02	06.65
22	03.40	94.80	95.04	95.20	94.35	94.86	94.74	98.50	03.62	10.50	08.00	06.90
23	02.80	94.78	95.35	95.35	94.50	94.90	94.65	98.70	03.40	11.00	08.80	07.25
24	02.20	94.70	95.60	95.16	93.80	94.90	94.60	98.75	03.30	11.70	08.70	07.55
25	01.81	94.62	96.05	95.00	93.50	94.90	94.60	98.45	03.40	12.32	08.45	07.65
26	01.36	94.50	96.30	95.04	93.42	94.90	94.55	98.40	03.60	12.85	08.50	07.40
27	00.96	94.48	96.25	95.00	93.20	95.00	94.50	97.80	03.85	13.25	07.55	06.90
28	00.56	94.62	96.02	94.92	93.25	94.75	94.50	98.50	04.15	13.70	06.84	06.45
29	00.28	94.95	96.05	94.90	93.58	94.90	94.50	.....	04.85	13.80	06.20	06.05
30	199.96	95.25	96.95	94.80	94.82*	94.95	94.48	.....	05.60	13.88	05.65	05.90
31	99.60	95.40	.....	94.75	.....	95.35	94.55	.....	06.10	.....	04.94	.....

*Ice gorged half mile below, November 30. Navigation was suspended on account of ice November 17, and remained so to February 26. Highest stages 214.25 feet, May 5. Lowest stages 193.20 feet November 29.

B.—*Record of gauge at Alton, Ill., for the fiscal year ending June* 30, 1881.

[Height of water above a plane 200 feet below the Saint Louis City directrix.]

Day.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	201.65	193.18	189.32	190.30	187.65	188.88	187.96	187.82	193.23	201.95	209.05	198.08
2	02.25	92.73	89.55	90.85	87.60	89.00	88.20	87.80	94.05	02.30	09.55	97.67
3	02.68	92.33	90.10	91.35	87.58	88.95	88.35	87.77	94.00	02.23	10.12	97.55
4	02.85	92.08	90.80	91.53	87.58	89.10	88.30	87.85	93.80	02.50	10.55	97.75
5	03.40	91.83	90.45	91.42	87.65	89.39	88.25	87.90	93.83	02.38	10.72	97.96
6	03.70	91.60	90.35	91.05	87.65	88.70	88.20	87.85	93.90	01.97	10.55	97.85
7	03.80	91.40	90.75	90.85	87.57	88.26	88.17	88.35	93.98	02.25	09.94	97.47
8	03.85	91.30	91.32	90.65	87.55	88.24	88.12	88.72	94.01	03.25	08.55	97.20
9	03.93	91.20	91.85	90.30	87.50	88.15	88.15	90.90	93.70	03.70	06.68	97.16
10	03.95	91.10	92.00	89.92	87.75	88.15	88.20	95.10	93.58	03.83	05.33	97.25
11	03.90	90.85	91.65	89.68	87.75	88.62	88.05	95.44	93.50	03.95	04.25	97.35
12	03.75	90.65	91.20	89.40	87.75	88.85	88.00	95.40	94.55	04.25	03.50	97.73
13	03.50	90.40	90.55	89.20	87.70	89.01	87.81	95.20	96.30	04.65	03.28	98.28
14	03.15	90.20	90.20	88.93	87.70	89.39	88.20	94.60	97.50	05.00	03.05	98.87
15	02.85	90.00	89.85	88.70	87.75	89.58	88.26	93.89	97.86	05.25	02.72	98.85
16	02.35	89.75	89.50	88.50	87.95	89.72	88.20	93.38	98.05	05.30	02.35	98.95
17	01.60	89.45	89.20	88.30	88.20	89.81	88.23	92.60	98.65	05.25	02.35	99.28
18	00.80	89.30	88.95	88.02	88.12	89.40	88.30	92.40	99.40	04.85	02.30	99.62
19	00.05	89.05	88.83	87.85	87.90	88.98	88.26	91.98	99.70	04.20	02.40	200.35
20	199.10	88.83	88.63	87.85	87.60	88.69	88.20	91.65	99.70	03.95	02.45	00.93
21	98.40	88.65	88.42	87.92	87.55	88.20	88.20	91.52	99.18	04.03	02.40	01.08
22	97.80	88.45	88.41	88.15	87.25	88.30	88.15	91.15	98.60	04.46	02.28	01.07
23	97.25	88.35	88.52	88.33	87.12	88.08	88.13	91.13	98.10	05.28	02.14	01.22
24	96.73	88.28	88.70	88.20	86.60	88.15	88.05	91.23	97.95	06.15	02.08	01.34
25	96.30	88.22	89.03	88.15	85.50	88.05	87.98	91.10	98.10	06.90	02.18	01.45
26	95.98	88.10	89.30	88.10	85.30	87.90	87.96	90.95	98.43	07.46	01.98	01.27
27	95.42	88.08	89.33	88.05	86.30*	87.70	87.95	91.30	98.45	07.90	01.48	00.78
28	94.40	88.10	89.15	88.02	87.85	86.65	87.90	91.89	98.55	08.30	00.70	00.38
29	93.80	88.63	89.05	87.95	88.50	86.45	87.87	.....	98.80	08.55	199.90	00.00
30	93.30	89.15	89.70	87.85	88.65	87.25	87.76	.....	99.50	08.75	99.17	199.68
31	92.93	89.20	.....	87.75	.....	87.75	87.75	.....	200.65	.....	98.60	.....

*Ice gorge below November 27. Navigation was suspended on account of ice from November 20 to February 26. Highest stage, 210.72 feet, May 5. Lowest stage, 185.30 feet, November 26.

C.—*Record of gauge at Gray's Point, Missouri, for the fiscal year ending June* 30, 1881.

[Height of water above a plane 200 feet below Saint Louis City Directrix.]

Day.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	109.16	103.21	99.01	97.26	95.11	89.46	88.81	93.66	102.46	109.76	117.66	107.66
2	9.71	02.86	99.06	97.91	94.96	88.86	88.96	93.56	03.46	11.96	17.91	07.26
3	10.41	02.51	99.11	98.41	94.86	90.21	89.06	93.56	04.36	12.51	18.36	06.81
4	11.01	02.01	99.86	98.61	94.71	90.56	89.96	93.26	04.66	12.26	19.01	06.76
5	11.41	01.61	100.12	99.46	94.61	91.36	91.01	93.51	04.61	12.11	19.41	06.96
6	12.06	01.41	00.26	99.36	94.71	91.86	91.91	94.31	04.26	11.91	19.96	07.66
7	12.56	01.11	00.01	99.31	94.76	92.16	92.16	93.16	03.96	11.41	20.26	07.71
8	12.76	00.96	99.66	99.21	94.56	92.16	92.16	93.26	03.76	11.76	20.31	07.46
9	12.91	00.76	100.26	99.16	94.66	91.66	91.96	94.31	03.56	12.66	18.66	07.26
10	12.96	00.66	00.96	99.01	94.61	92.16	91.86	97.26	03.16	13.26	17.06	06.96
11	12.86	00.66	01.36	98.66	94.71	93.21	91.81	103.26	02.71	13.56	15.16	06.91
12	12.76	00.36	01.26	97.86	94.76	93.11	92.16	06.76	02.26	13.96	13.86	06.91
13	12.66	00.21	00.66	97.41	94.81	92.86	92.31	06.96	02.46	14.31	13.46	07.00
14	12.36	00.01	00.06	97.26	94.86	92.76	93.01	05.66	04.26	14.91	13.06	08.31
15	12.16	99.76	99.36	97.11	94.81	91.76	93.36	04.96	06.81	15.61	12.26	08.31
16	11.86	99.56	98.91	96.86	94.96	91.81	93.46	04.26	07.66	15.91	11.66	08.41
17	11.51	99.36	98.66	96.66	95.16	92.16	93.41	03.36	07.96	16.16	11.56	08.36
18	10.91	99.06	98.46	96.26	95.36	92.46	93.46	03.06	08.26	16.36	11.31	68.46
19	10.26	98.66	98.36	95.96	95.06	92.76	93.46	02.91	09.46	16.01	11.11	08.66
20	09.86	98.36	98.26	95.66	94.71	92.96	93.41	02.51	10.26	15.21	11.01	09.66
21	08.96	98.06	97.91	95.56	94.66	92.71	94.06	02.31	10.31	14.56	10.91	10.61
22	08.26	97.86	97.56	95.56	94.56	92.51	94.26	02.36	09.96	14.46	10.81	10.76
23	07.71	97.86	97.16	95.51	94.31	92.31	94.21	02.36	09.46	14.66	10.61	10.66
24	07.21	97.66	96.91	95.66	93.46	92.16	94.41	02.41	08.96	15.21	10.51	10.66
25	06.76	97.51	96.86	95.86	93.16	92.06	94.51	02.16	08.66	16.01	10.41	10.56
26	06.41	97.31	96.96	95.86	92.56	91.96	94.46	02.26	08.76	16.56	10.66	10.61
27	06.16	97.16	97.21	95.76	91.56	91.86	94.66	02.21	08.91	16.96	10.21	10.56
28	05.81	97.16	97.36	95.66	91.16	91.86	94.56	01.96	08.86	17.11	09.81	10.16
29	05.16	97.11	97.31	95.56	90.46	91.66	94.36	.....	08.86	17.26	09.11	09.91
30	04.46	97.56	97.16	95.41	89.96	90.46	94.11	.....	08.81	17.41	08.31	09.56
31	03.66	98.26	.....	95.26	.....	88.26	93.81	.....	09.16	.....	07.36	.....

The river was frozen during parts of November and December, but no record was kept of the dates and from January 1 to February 11.

Highest stage, 120.31 feet, May 8; lowest stage, 88.26 feet, December 31.

D.—*Depth of water upon the bars between Sain*

Date.	Stage above low-water of 1863, by Saint Louis gauge.	Name of steamer furnishing report.	Arsenal Island (head.)	Arsenal Island (foot).	Horsetail.	Widow Beard's.	Jim Smith's.	Bridgewater or Foster's Island.	Herculaneum (Swashm).	Cornish Island.	Selma (Kennett's Castle.)	Forest Home.	Perry's Towhead.	Rushtowe's Bend.	Fort Chartres.	Turkey Island.	Saint Genevieve Island.
1880.																	
Aug. 2	16.1	Humphreys	....	....	12½	....	....	....	....	....	....	....	....	....	....	....	....
3	15.6	....do	....	....	....	18	15	....	10	....	....	13	....	....	8	....	....
6	14.7	....do	....	13	....	16	14	....	7½	....	10½	12	16	....	10½	....	....
7	14.5	....do	....	....	....	16½	14	....	6	....	10	13	13	....	12	....	....
9	14.2	....do	....	....	11	....	....	....	....	....	....	....	....	....	....	....	....
10	14.1	City of Greenville ..	10½	15	9½	....	15	....	12	10½	....	12	....	....	10½	....	15
11	14.0	Humphreys	....	....	....	18	15	....	....	....	9	....	....	....	10½	....	....
11	14.0	Commonwealth	12½	....	....	....	....	....	9	....	7	....	12	....	10½	....	13½
11	14.0	City of Alton	....	13½	....	15	12	....	10½	9	10	....	9	....	9	13½	13½
12	13.7	Humphreys	....	....	....	....	12	....	9	....	9	8½	....	....	....	....	....
13	13.5	City of Providence..	12	15	....	....	....	....	7	....	7	....	8	....	8	....	....
15	13.0	Grand Tower	10½	....	....	....	....	....	12	....	9	....	9	....	10½	....	....
15	13.0	Golden City	....	....	....	....	....	....	....	9	....	9	....	....	9	....	8
16	12.8	Humphreys	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
17	12.5	....do	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18	12.1	....do	....	....	....	....	....	....	7½	....	8	12	12	....	9	....	....
18	12.1	City of Helena	12	....	....	....	....	....	8	....	7½	12	10½	....	7½	....	....
19	11.7	Humphreys	....	....	....	12	12	....	8	....	8	12	12	....	9	....	12
20	11.5	Gold Dust	....	9	....	9	....	....	6½	....	....	....	7	....	8	....	....
21	11.2	Humphreys	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
22	10.9	....do	....	....	....	9½	12	....	7	....	7	12	8½	....	8	....	12
22	10.9	City of Greenville...	8½	9	10½	....	....	....	8½	....	8	....	10½	....	7½	....	....
23	10.7	Humphreys	....	....	....	12	10½	....	8	....	8	12	8	....	8	....	12
23	10.7	City of Greenville...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
24	10.4	John B. Maude	....	8	....	9	....	....	6½	....	7	....	9	....	6½	....	....
25	10.4	Commonwealth	....	....	7	....	....	....	6½	....	6½	....	8½	....	6½	....	10½
26	10.4	City of Providence..	....	....	....	....	....	....	....	....	....	....	8½	....	8	....	....
27	10.4	Humphreys	....	....	....	12	10½	....	7	....	7	9	7	....	7	....	10½
27	10.4	Belle of Shreveport.	....	....	....	15	15	....	6	....	9	12	10½	....	6	....	7½
28	10.5	Humphreys	....	....	....	9½	10½	....	8	....	7	8	7½	....	7	....	....
28	10.5	Grand Tower	9	13½	....	9	....	....	7	....	6	....	9	....	6½	....	....
30	11.9	Wyoming	7	....	8	8	....	....	....	....	....	....	....	....	8	....	....
Sept. 6	13.25	John B. Maude	9	12	....	....	....	....	8½	....	....	10½	....	....	8	....	....
7	13.50	Humphreys	....	....	....	12	12	9	9	....	10½	12	13½	....	9	....	15
8	14.25	Annie P. Silver	....	....	....	....	....	....	....	....	....	....	....	....	10½	....	....
11	14.58	Grand Tower	....	....	....	....	....	12	10½	....	....	....	....	....	8½	....	....
13	13.25	Humphreys	....	....	....	13½	13½	9	8	....	10½	12	9	....	9	....	15
13	13.25	John B. Maude	13½	....	....	....	....	10½	10½	....	12	13½	....	....	10½	....	....
14	12.75	Humphreys	....	....	....	13½	13½	9½	9½	....	10½	15	10½	....	8	....	15
15	12.25	John A. Scudder	....	....	....	....	....	....	8	....	9	....	....	....	....	....	....
15	12.25	City of Helena	....	....	....	....	....	....	8	....	9	....	....	....	10½	....	....
16	11.83	Humphreys	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
17	11.50	....do	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18	11.00	....do	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18	.....	Chas. P. Chouteau...	8½	....	7	....	....	7½	6½	....	....	....	....	....	5½	....	....
21	10.33	City of Alton	12	8½	8	....	12	8	9	....	8	....	9½	....	8	....	12
21	.....	Commonwealth	8	9	6½	10½	....	6	6	....	9½	....	10½	....	7	....	....
22	10.17	Humphreys	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....
23	10.00	....do	....	....	6	9½	9	8	7½	....	8	12	7½	....	8½	....	9½
23	10.00	Colorado	....	....	6	....	....	7	6	....	6	....	12	....	....	....	....
24	10.8	Humphreys	....	....	5	9	9	8½	7	....	8	12	7	....	....	....	....
24	10.8	City of Providence .	9	12	7	10½	....	....	6½	....	7½	....	....	....	8	....	....
25	10.33	W. P. Halliday	7	10½	6	9	....	....	7½	....	7½	9	9	....	6½	....	9
26	10.58	Grand Tower	8	....	7	9	....	....	7½	6½	7	....	....	....	7	....	....
27	10.58	Humphreys	....	....	7½	9½	12	8½	8	....	9	13½	8½	....	8½	....	9½
27	10.58	John B. Maude	9	10½	7	....	....	9	6	....	8	....	....	....	7	....	....
28	10.50	Humphreys	....	....	8	10½	12	9	8½	....	8	12	8	....	7½	....	....
28	10.50	City of Helena	9½	....	6½	....	....	....	....	....	6½	....	....	....	8	....	....
29	10.42	Humphreys	....	....	6½	....	....	....	....	....	....	....	....	....	....	....	....
30	10.83	....do	....	....	6½	10½	8½	9½	8½	....	9	12	10½	....	9½	....	10½
30	10.83	Colorado	8	....	6½	....	....	7	....	....	....	....	....	....	....	....	....
Oct. 2	11.75	Humphreys	....	....	7	12	9½	9½	8½	....	10½	10½	9	....	9	....	12
3	12.17	....do	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4	12.50	....do	....	....	9	....	10½	10½	....	....	10½	12	15	....	12	....	12
6	12.10	Commonwealth	....	....	9	....	....	9	9	....	10½	....	10½	....	9	....	9
7	12.10	Humphreys	....	....	....	10½	12	8½	10½	....	9½	15	15	....	10½	....	13½
9	11.67	Grand Tower	8	....	7½	....	....	7½	8	....	....	....	....	....	7	....	....
10	11.00	Centennial	8	12	6½	8	....	....	7½	7½	9	....	10½	....	8½	....	10½
11	10.67	Humphreys	....	....	7½	9	10½	9½	9	....	9	12	13	....	8	....	12
12	10.33	....do	....	....	8	9½	9½	7	9½	....	10½	12	12	....	8	....	12
12	10.33	City of Alton	9	....	6½	....	....	7	7½	....	9½	....	7½	....	9	....	12

Louis and Cairo, as reported by pilots.

Saint Genevieve Bend.	Kaskaskia Island.	Saint Mary, Rozier's.	Mary's River (Blocks).	Liberty Island.	Jones' Point.	Hat Island.	Crawford's.	Moccasin Springs (Bee).	Swift Shore.	Kinney Point.	Floral Creek.	Cape Girardeau (Wahoo).	Jacket Pattern.	Goose Island.	Saladine Towhead.	Thompson's.	Scudder Towhead.	Greenleaf's.	Abel's Towhead.	Pond Lily.	Eliza Point.	Greenfield.
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.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	9	9	12	9½	9½	12	13½	12	....	12	12	9	8	12	15	13½	12	7½	....	....	8	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	9	....	....	8½	8½	10½	9	9½	12	12	13½	10½	9½	13½	....	13½	....	....	....	....	6½	....
9	8	10½	12	8½	10½	10½	10½	8½	9½	12	10½	10½	8½	10½	....	13½	....	....	....	9	7	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	9	10½	....	8	9	13½	10½	9	9	13½	9	9	7	12	....	12	12	10½	....	7	7½	....
7½	9	10½	10½	10½	7½	12	12	9	10½	....	10½	9	9	12	16½	10½	12	....	....	....	....	....
.....	7½	....	9	9½	....	9½	9½	....	....	....	10½	....	8	....	....	....	....	....	....	....	....	....
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8	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13½	7½	....	....	9	8	10½	9	8	....	....	7	....	7½	....	....	....	....	....	....	9	6½	....
8	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	7½	....	....	9	8	12	9	6½	....	....	9	8	6½	9	....	....	....	....	....	....	....	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	7	....	....	7½	8½	10½	10½	....	....	....	8	....	....	....	....	....	....	....	....	....	....	....
10½	....	8½	....	8½	....	9	9	6½	....	....	....	....	....	....	....	....	....	....	....	....	....	....
.....	6½	....	....	....	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	9	12	9	9	6½	9	10½	10½	....	....	....	6	6	....
9	....	6	7½	8	6	9	8	5½	8	8	9	6	....	5½	....	9	10½	13½	....	6½	5½	....
10½	6	....	8½	6	6	8½	8	6	7	9½	7	6	5½	8	9	12	....	....	....	5½	5	....
.....	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
.....	6½	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10½	5	....	6½	9	5½	9	7	6	....	9	9	9	6	10½	10½	9½	12	....	9	....	....	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10½	6	....	....	....	6	10½	10½	5	9	10½	9	6	6	8½	8	10½	....	....	....	6	6	....
10½	6	....	....	....	6	10½	10½	5	9	10½	9	6	6	8½	8	10½	....	....	....	6	6	....
.....	7	....	....	....	8	10½	....	6½	....	....	....	8	7	....	....	....	....	....	....	6	5	....
10½	7	....	....	....	9	....	....	7	....	....	....	....	9	10½	....	....	....	....	....	8½	....	9
.....	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13½	....	....	....	10½	....	....	....	....	....	....	12	....	9½	....	....	....	....	....	....	....	10½	....
.....	9	....	....	10½	....	....	....	10½	....	....	....	....	10½	....	....	....	....	....	....	13½	9	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	9	....	....	12	....	....	12	8½	....	12	12	10½	7	13½	....	....	....	....	....	....	....	7
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	9	....	....	8	....	....	....	....	....	....	....	....	9	....	....	....	....	....	....	9	9	....
.....	9	....	....	7½	....	....	....	8	....	....	....	....	9	....	....	....	....	....	....	....	....	9
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
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.....	7½	.....	.....	7½	.....	.....	8	4½	8½	.....	.....	7½	6	.....	.....	.....	.....	.....	.....	7	.....	.....
12	9½	....	10½	12	8	12	10½	7½	9	12	8½	9	9	12	....	....	....	....	....	....	....	....
9	8	....	9	....	6½	9	9	5½	6½	....	10½	6½	5½	10½	....	12	....	....	....	6½	6	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	8	....	....	....	6	....	7	5½	8	....	9	....	7	....	....	....	....	....	....	....	5	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	8	....	10½	....	6½	9	7	6	7½	12	....	6½	....	9	....	12	....	9	....	6	5½	....
9	7	....	8	....	6½	9	6½	6	7	9	8	6	7	....	....	....	....	....	....	6½	5¾	....
10	7	....	9	....	6	10½	....	5½	8	10½	10½	7	7	10½	10½	....	....	....	....	6½	5½	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	6	....	....	....	5½	....	8	....	7½	9	9	7½	6	9	....	....	....	....	....	6½	5¾	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	....	....	....	....	6	9½	8	6½	6	....	9	6	6½	8	....	....	....	....	....	8	5¾	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	8	....	....	....	5½	....	7½	5½	8	8	9	6	7	9	....	....	....	....	....	7	6	....
.....	9	....	....	...	....	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
.....	....	....	....	....	....	....	12	....	....	....	12	....	9½	12	....	12	....	....	8	....	....	....
.....	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
.....	....	....	....	....	9	....	8	7	9	9	10½	8	8	9	....	12	....	....	....	8	8	....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	7½	....	....	....	8	....	8	7½	....	....	....	8	7½	....	....	....	....	....	....	....	6	....
10½	9	15	8	9	7	12	7½	7	9	12	10½	8	8	....	12	15	13½	....	....	9	....	....
.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	....	....	9	7½	....	10½	6½	7	....	12	12	6½	7½	....	....	....	13½	....	7	7	8	....

D.—*Depth of water upon the bars between Saint*

Date.	Stage above low-water of 1863, by Saint Louis gauge.	Name of steamer furnishing report.	Arsenal Island (head).	Arsenal Island (foot).	Horsetail.	Widow Beard's.	Jim Smith's.	Bridgewater or Foster's Island.	Herculaneum (Swashin).	Cornish Island.	Selma (Kennett's Castle).	Forest Home.	Perry's Towhead.	Rushtower Bend.	Fort Chartres.	Turkey Island.	Saint Genevieve Island.
1880.																	
Oct. 13	10.17	City of Helena	....	....	6½	....	....	....	....	....	....	....	....	....	7½	....	....
14	9.92	Colorado	....	....	6½	....	....	7½	7½	....	7½	....	....	....	8	....	....
15	9.67	Humphreys	....	....	6	9½	9½	8½	8	....	9	12	12	....	8	....	12
15	9.67	Gold Dust	7½	....	6½	....	....	8	7	....	8½	....	....	....	8	....	....
16	9.67	Humphreys	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
17	9.33	Joe Kinnay	....	....	6½	....	....	8	6½	....	7½	....	....	....	8½	....	....
18	8.92	Humphreys	....	....	6½	....	....	....	....	....	....	....	....	....	....	....	....
19	8.83	....do	....	....	6	10½	....	....	....	....	....	....	....	....	....	....	....
19	8.83	Annie P. Silver	....	....	5½	9	....	6	5½	....	....	....	6	....	8	....	....
20	8.92	Humphreys	....	....	....	....	8	7	7½	....	10½	9½	9½	....	7½	....	9½
20	8.92	Commonwealth	7	....	6	8	....	....	6	....	8	7	7	....	8	....	....
21	8.83	Humphreys	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....
21	8.83	Colorado	8	....	5½	....	....	6½	6	....	7	....	....	....	8	....	....
22	9.00	Humphreys	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....
23	9.25	....do	....	....	6½	9	9	7½	6½	....	9½	9½	7½	....	6½	....	9
24	9.25	....do	....	....	7	8	9	7	8	....	....	12	9	....	6½	....	9
24	9.25	Guiding Star	....	....	6	....	....	6	6½	....	8	....	9	....	....	....	....
25	9.17	J. B. Maude	8	12	5½	9	....	7½	7	....	6	....	10½	....	8	....	....
27	9.00	Humphreys	....	....	6½	10½	9	6½	6	....	....	....	8	....	6½	....	....
27	9.00	City of Helena	7	....	6	....	....	....	7	....	8	....	9	....	9	....	....
28	8.92	Humphreys	....	....	6½	8½	8	7	6	....	....	....	....	....	....	....	....
29	8.75	John A. Scudder	6½	8	5½	10½	....	....	....	7	6½	....	....	....	8	....	....
30	8,58	Humphreys	....	....	6	7	8½	6	6	....	....	....	7½	....	8½	....	10½
31	8.42	....do	....	....	6	7½	8½	6	6	....	6½	....	7½	....	8½	....	12
31	8.42	Golden City	8	....	5½	9	....	7	6½	7	....	9	9	....	9	....	....
Nov. 1	8.33	Centennial	6	9	6	8	....	....	6½	....	....	....	10½	9	8	15	....
2	8.25	Commonwealth	7	....	6	8	....	....	7	....	7	....	....	....	....	....	9
3	8.17	City of Alton	7	....	6	12	10½	7	7½	....	....	8	7	....	7	....	....
4	8.10	Humphreys	....	....	6	9½	7	5½	6	....	6½	....	7½	....	7	....	8½
5	8.17	....do	....	....	6	9	7	6½	7	....	6	....	7½	....	7½	....	8½
5	8.17	James Howard	7	9	6	6½	....	7	6	....	7	....	7	....	7	....	9
6	8.17	Grand Tower	6½	7½	5½	....	....	....	5½	....	6	....	9	....	8	....	8
7	8.10	W. P. Halliday	6½	....	6½	....	....	6	6	....	6	....	9	....	....	....	7½
8	8.00	Humphreys	....	....	6	....	....	....	....	....	....	....	....	....	....	....	....
10	8.17	City of Helena	8½	....	....	....	....	....	6½	....	6	....	....	....	9	....	10½
11	8.25	Humphreys	....	....	5½	9	9	5½	6	....	7	....	9	....	6	....	8½
11	8.25	Annie P. Silver	6	6	5½	7½	9	5½	6½	....	....	....	8½	....	7	....	....
12	8.17	Humphreys	....	....	....	....	....	....	....	....	7	....	8	....	7	....	8½
13	8.17	....do	....	....	6	8½	9	6	6½	....	....	....	....	....	....	....	....
15	8.42	....do	....	....	5½	10½	10½	6½	6½	....	6½	....	8	....	6½	....	10½
16	8.50	....do	....	....	6	10½	10½	7	7	....	7½	....	8	....	7	....	....
17	8.75	Centennial	....	....	....	10½	....	....	6	....	7	....	8	....	7½	....	9
19	8.33	John A. Scudder	....	....	7	....	....	....	8	....	8	....	....	....	....	....	....
26	5.10	Humphreys	3½	....	5	....	....	....	....	....	....	....	....	....	....	....	....

Louis and Cairo, as reported by pilots—Continued.

Saint Genevieve Bend.	Kaskaskia Island.	Saint Mary, Rozier's.	Mary's River (Blocks).	Liberty Island.	Jones' Point.	Hat Island.	Crawford's.	Moccasin Springs (Bee).	Swift Shore.	Kinney Point.	Floral Creek.	Cape Girardeau (Wahoo).	Jacket Pattern.	Goose Island.	Saladin Towhead.	Thompson's.	Scudder Towhead.	Greenleaf's.	Abel's Towhead.	Pond Lily.	Eliza Point.	Greenfield.
8½	7½	....	....	7½	....	12	....	6½	8	....	....	7½	....	....	....	....	....	....	....	6½	7½	....
....	8	....	....	....	7½	....	6	7	....	8	....	6½	7	9	....	....	....	....	6½	6½	....	....
8	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	6½	....	9	....	8	....	8	7	8½	....	....	7½	8	9	....	....	....	....	....	6½	7½	....
....	....	....	....	....	7	10½	8	....	9	....	9	7	8	9	10½	12	10½	....	....	8	6½	....
9	8½	....	....	....	7	....	....	7	....	....	....	6½	6½	....	....	....	....	....	....	5½	8	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8½	6	....	....	....	6½	....	6	5½	7	....	9	....	6	6	....	....	....	....	8½	5½	6½	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	6	....	8	8	6½	7	5	5½	7	9	9	5½	6½	8	9½	12	10½	....	5	7	6½	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	6	8	6	5	7½	....	7½	5	....	....	....	....	....	....	....	6	7½	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	....	....	7½	....	7	....	7	7	....	9	9	6	7	8	....	....	....	10½	8	7	7	....
9	6	....	8	7	6	10½	6	5½	7	....	8	5½	7½	8	....	....	....	....	....	....	....	....
8½	6½	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8½	....	....	....	7½	6	12	6	5½	6	....	8	6	6	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7	6	....	7½	7½	6½	8	6	6	7½	....	6½	5	6	6½	....	9½	12	....	....	6½	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	6	....	8	....	5½	....	....	5½	....	8	....	5½	7	8	....	....	....	....	....	6	7	....
8	8	....	7½	....	....	7	5½	6	7½	10½	9	6	7	7	9	12	....	....	10½	7½	7½	....
....	7½	....	7	6	6	9	6	5½	....	9	6	5½	7	....	....	....	....	....	....	....	....	....
....	6	....	7	6	6	9	6	5½	....	9	6	5⅓	6½	7	9	9	....	....	....	6	9	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	6½	8	7	7	....	....	6	5½	....	8	8	5	7	7½	....	10½	....	10½	8	7	8	....
....	5½	....	....	....	6½	....	6	5½	7	....	7	5⅓	6	7	10½	....	10½	....	10½	6	7	....
....	6½	....	8½	....	5½	8½	6½	5½	6	....	7½	5½	6¼	8	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	6½	6	6	....	6	....	....	5½	....	....	....	5½	6	8	....	....	....	....	12	9	10½	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7½	7½	....	....	....	5½	....	5½	5¼	....	....	....	5½	6	6	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	7	....	7½	....	7½	10½	7½	6½	....	9	8	6	....	8	....	....	....	....	10½	9½	10½	....
....	8	....	....	....	7½	9	7½	7	....	....	....	5¼	7½	....	....	....	....	....	....	8½	9½	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

E.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *August* 2, 1881.

CAPTAIN: I have the honor respectfully to submit my annual report of operations conducted under your direction during the fiscal year ending June 30, 1881, relating to improving the Mississippi River at Horsetail Bar, and to constructing and repairing equipment pertaining to the improvement of the same river between the Illinois and Ohio rivers.

I. IMPROVING THE MISSISSIPPI RIVER AT HORSETAIL BAR.

INTRODUCTION.

The operations for improving the Mississippi River at Horsetail Bar having run through a series of years, rendering repetitions of details of the forms of construction used prior to this year necessary should an attempt be made to make this report complete within itself, adding greatly to its volume without contributing knowledge not otherwise easily accessible, it has been prepared with a view to having it considered as a continuation of former reports of operations at this locality.

Work was not entirely suspended at the close of the last fiscal year. A small force was retained during the high stage of the river to watch the work and construct curtains to be used either in repairs or in construction, as circumstances might require.

Still field work was practically suspended until the end of July, when the force was largely increased and active operations were resumed.

In the mean time a supply of curtains had been accumulated and the works had been closely watched during the high stages by the force named.

A concise statement of the condition of the works at this time, about the 1st of August, and of the accretions formed during the period of inactivity form an appropriate introduction to the detailed statement of the work done and the results obtained during the year just closed.

The curtains forming the primary line of hurdles* continued to have an edge buoyed at the surface of the water during the greater part of the flood stage. The buoys, which are the weak points in that system, failed only after long continued strain, due to the force of the current with the drift-wood and other *débris* carried by it, which increased as the river rose, while the position assumed by the curtains in a rising river lessens their ability to withstand such strain. At last the buoy lines were broken by the continual surging of the waves. Still the edges of the curtains remained near the surface until an accumulation of sediment, rootlets, driftwood, and other heavy material destroyed their buoyancy, about the 1st of August, or at the time that field work was resumed, though some of them sunk a little earlier than this, while others were efficient considerably later. There were no gaps in the primary line from which the curtains had been swept, but the whole was worn out in service, furnishing an indication of the limit of the service which may be expected of works relying upon buoys as supports when the buoys are held by means of sisal ropes, which was used here.

The lower section of the solid wall, however, had settled, so that not more than 400 feet of it appeared above water at an 8-foot stage.

On examining the secondary hurdles in rear of the primary line a small channel-way was found to have been opened through rows Nos. 11 to 19 inclusive, its location corresponding very nearly with the western or outer edge of the sand-bar as it existed during the spring season. This channel was not more than 50 feet wide at its upper end, but increased to 300 feet at its lower end and became dry when the river fell to about 4 feet above low-water. There was another depression in the bar near shore, with breaches in lines Nos. 18 and 19.

The water collecting into one body above dike No. 3, passing through the gap near its outer end, divided again into two unequal portions, the smaller passing closely under the dike to shore, breaching lines Nos. 20, 21, and 22, dividing again below the last-named line, a portion rejoined the main body above line No. 23, leaving that line unkroken, while the other portion, after passing through line No. 23, broke lines Nos. 24 to 27, inclusive.

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* Designated "training-wall" in former reports, a designation which is still retained for the solid portions, but that portion constructed permeable is called primary hurdles in this report. This name will be applied to hurdle lines, whose direction approaches parallelism with the course of the stream, transverse lines being called secondary hurdles.

The breach in line No. 27 was very interesting. The piles were scoured or lifted by their bouyancy out of place and capsized, while the horizontal rods of the brush held, leaving a section of hurdles afloat but securely moored. The rods yielded by stretching, permitting it to swing slightly down stream with the position of the piles inverted, the points turned up and the butts down, in which position it acted as efficiently in forming a bar as did the unbroken portion of the line, being completely closed in by a deposit of sand.

The main body of water, after passing through dike No. 3, continued through lines Nos. 20, 21, and 22, following about the same direction as the old channel-way on the east side of the lower section of the training-wall, and being there joined by a large body of water passing through the open curtains below the dike, which having swept the outer ends of these same lines in its passage had broken them off; the body thus increased in volume swept past the outer ends of all the hurdle lines from No. 23 to No. 27, inclusive, breaking short sections from each of them; this body of water then divided into three not very unequal portions: the first, turning to the left, went to join the waters flowing down the inshore channel and passed out to the east of Carroll's Island; the second, flowing straight ahead through a depression in dike No. 4, then deflecting to the right, rejoined the navigable channel* below Jefferson Barracks, while the third, turning squarely to the right, recrossed the line of the training-wall above dike No. 4, and thence direct to Jefferson Barracks.

Examining these channels they are found to follow closely the traces of old navigable channels in which the river flowed at low stages before the construction of the works when the waters free to move followed the lines of least resistance.

The persistency with which they tried to follow these same lines shows that the cause remains to a certain extent, and the necessity of guarding against their reopening still exists.

These channels were not formed by any considerable scour, but by the deposits being less there than on other parts of the space in rear of the primary line, hence their location marks that of the bars which covered all the space between them. The heights of the bars were irregular; eastward of the channel, through hurdle lines No. 11 to No. 19, is a large bar which existed last spring, representing in a marked degree the results of works constructed during the year 1879. Its crest would have been dry with the river at a 17-foot stage previous to the high-water of this year, but after that rise it was found to be 20 feet above low-water from its upper end near the coal dump to dike No. 2, filling all the space in rear of the training-wall, except a small triangular piece just above the dike, having a length of 600 feet on line of the wall and 150 feet on line of the dike. The bar is cut here by the "Prairie Du Pont" Creek which persistently keeps a passage open immediately under the dike. From that creek the crest gradually rises to the south until it reaches an elevation of 22 feet above low-water at secondary hurdle line No. 10; continuing at that height to about line No. 17, it dropped to 18 feet at line No. 19, below which it was submerged by the water coming through the chute or channel-way passing near shore on its way to the gap in dike No. 3.

This bar sloped from the crest to about 14 feet above low-water in the depression near shore, and to about 4 feet above the same plane in the channels near the west side of the old bar. Thence westward another bar reared its crest to 20 feet above low-water, extending from secondary hurdle line No. 11 to line No. 16, whence it sloped downward to be submerged at line No. 19 by water passing through the curtains in the primary hurdles, seeking an outlet through the breach in dike No. 3. This bar sloped from 20 feet at its crest to about 6 feet above low-water at its upper end.

Below dike No. 3 the traces of the channels still determine the locations of the bars. There was a large bar o nthe west side of the slough which passed near shore, commencing near the dike where its crest was about 17 feet above low-water. It rose to 22 feet at secondary line No. 24, and was submerged between lines Nos. 26 and 27. This bar was irregular in height, following to some extent that of the hurdle lines. It extended to a distance of about 1,000 feet from shore and terminated with an abrupt slope to the westward. Another bar was nearly dry at this time under the outer end of dike No. 3, and above secondary line No. 21. From dike No. 4 to the head of Carroll's Island immense deposits were made forming an unbroken bar from the island to within a short distance of the dike, entirely dry at the present stage of river, and at the lower end rising to 20 feet or more above low-water.

The foregoing bars and channels cover all the space upon which the works were intended to act directly by inducing deposits of portions of the material held in suspension, sufficient in quantity to convert the whole into solid ground-leaving that portion of the training-wall or primary hurdle line and the Missouri shore-line open to the outflow of the river, in which its channel could be traced, wherever it found the obstructions least, the only condition imposed in the interest of the works being that it should

*All water passages other than the navigable channel, if having considerable current, are called channels.

collect in and form at least one channel suitable for navigation. However, as the relation between the channel thus formed and the works is an intimate one, scarcely any movement of the navigable channel is possible which would not affect the works, either beneficially or otherwise.

Hence the study of the contours of the river bed, outside of the work, is inseparably connected with that of the forms of construction most suitable for the purpose under any particular circumstances which might be presented.

Commencing at the coal dump, a large bar extended down on the east side of the river, intersecting the training-wall at about its junction with secondary hurdle line No. 16, which pushed the channel towards dike No. 1, where it spilled over a reef projecting from the outer end of the dike to a point on the training wall near its intersection with secondary hurdle line No. 22. Another reef projected from the primary hurdle line nearly in the direction of secondary line No. 19 produced, until it intersected that coming from dike No. 1. A third reef commenced at a short distance from the Missouri shore, about where secondary line No. 18 would intersect it if produced, thence projecting to cut the line of the training-wall at its junction with secondary hurdle line No. 23.

The navigable channel was run by descending boats by starting out from the docks as if to cross the primary line of hurdles at its intersection with secondary line No. 17, until about mid-stream was reached, when, throwing the head upon the flag-staff at Jefferson Barracks and allowing the stern to drop to the Government Light near the upper end of the training-wall, this course was held till both reefs were crossed, when it was changed to become parallel with the shore.

On the east side of the navigable channel and on the lower side of the lower reef a bar extended below the line of dike No. 4, its eastern edge being about 300 feet from the training-wall at its nearest point. Another bar lay off the end of dike No. 4, between the channels passing from the primary line of hurdles to the Barracks, and that passing through the dike to join the navigable channel a little further down.

Leaving the navigable channel just below the upper reef, a large body of water was deflected toward the primary hurdles, and owing to the convergence of the two reefs, was thrown against them in the form of a jet, not with sufficient velocity at this particular time to scour the bed of the river, but certain changes later with a falling river gave it a velocity which threatened the destruction of the works.

The accompanying sketches were traced from Plate 2, being designated Plates 6, 7, 8, and 9, respectively. They were made from surveys and examinations to show the condition of the works and state of deposits, each, at the date to which it refers. The stage of river in all of them was reduced to 11 feet above the low-water of 1863 for the purpose of comparison, which was the prevailing stage during the time that the survey of March, 1880, was made. Sketch 6 shows the condition of the works and the state of deposits on that portion of the inclosed areas above dike No. 4, June 30, 1880, from surveys of that date with the river about 22 feet above low-water; but the survey not extending farther down, the part of the sketch below was made from the survey of March, 1880, the position of the navigable channel during the fall of 1878, the spring, summer, and fall of 1879, and during the spring and on June 30, 1880.

Sketch 7 is based upon an examination when field work was resumed about the 1st of August with the river about 16.5 feet above low-water, and though not made instrumentally, it is a close approximation to accuracy, the location of many of the points on it being known from previous surveys. This sketch shows the location of the bars which would become dry at the reduced stage, the navigable and other channels, the crests of the sand reefs projecting from dike No. 1, and the intersection of secondary line No. 19 with the primary line, and of that projecting from the Missouri side toward the intersection of secondary line No. 23 with the primary line, together with the condition of the secondary hurdles after the summer flood had passed.

Sketch 8 is from an examination made November 29 after the close of field operations for the fall season, with the river about 3 feet above the low-water of 1863. The bars shown on this would have been dry with the river 11 feet above low-water. The additional areas of bars dry when the examination was made are not shown on the sketch. All of them were somewhat larger without changing their elevation, owing to the lower stages of water exposing zones whose width increased or decreased as the slopes of their sides were flat or steep. But in notable instances the bar was larger on account of material deposited during the season, but which did not have sufficient height to appear above the surface with the river at the stage assumed for these sketches. There was a gravel-covered sand ridge just inside the primary hurdle-line from its upper end above dike No. 3 to dike No. 4; its lower end being then about 2 feet above water and its crest rising to about 12 feet above low-water at dike No. 3, which height extended to its upper end.

1. LOCATION AND EXTENT OF WORKS CONSTRUCTED DURING THE YEAR.

A description of the field operations conducted during this fiscal year cannot well ignore their chronological order and still be intelligible.

The year was divided into two distinct working seasons by the intervention of a long severe winter, closing the river to navigation of any kind by forming gorges of ice and freezing it solidly over its whole surface, not only preventing field work while closed, but upon its breaking up in the spring damaging that which had been done, and necessitating that the work of the second half year should be largely devoted to repairs. For these reasons the work done during each half year has been described separately.

On the 2d day of August 2 pile-drivers were towed to Horsetail Bar and commenced driving piles in the breaches in secondary hurdle lines Nos. 18 and 19, first in the slough near the shore, and afterwards in the channel west of the large bar; these breaches having been closed, the drivers were dropped down and work was begun upon the shore ends of lines Nos. 21 and 22, when two other drivers were also brought down and commenced repairing the lines from No. 20, south of the west side of the bar and extending them to deep water. In the mean time the work of placing curtains in the primary line of hurdles was begun at the lower end of the upper section of solid wall. They were held in position by anchors, and their tops were supported by buoys following the form of construction used during the preceding year, using woven curtains exclusively.

The work progressed in this way down to its intersection with secondary hurdle line No. 19, where, in order to give increased durability to the line, piles were driven in clumps of 3 each, spaced 15 feet between centers in rear of all except two of the curtains which had been placed, and the curtains were firmly lashed to them, and from that time to the close of the first half of the fiscal year piles were driven in advance of the placing of curtains, in clumps of 3, in pairs or singly, and spaced 15, 10, or 5 feet as circumstances demanded, the 5-foot spaces being used, however, only near dike No. 4, where the small depths rendered fixed hurdles a suitable form of construction.

The works of the last fiscal year would have repaid for their expenditure if they had accomplished no other result than rendering practicable this modification of the form of construction by which piles were used as supports for the curtains, increasing the duration of their efficiency and serving to a great extent in place of anchors and buoys, which was due to decreasing the depths on the line and in rear of the primary line of hurdles from which a radical change in the direction of the currents followed toward parallelism with the primary line, thereby greatly lessening the pressure upon it, though depths still remained great on the primary line between secondary lines Nos. 20 and 23, on account of which considerable difficulty was encountered in placing curtains, and several breaches occurred in that part of the line from the current pressing the curtains against the piles with sufficient force to break them.

The force with which they were pressed was most excessive when closing the gap at the upper end of the lower section of the solid wall. The depth of water in the gap was about 25 feet and that on the solid wall below from 2 to 5 feet. One curtain driven by this current against the piles broke the first clump with which it came in contact and which projected a little beyond the general alignment. This clump was composed of three sound green sycamore and oak piles, each about 14 inches in diameter. Another curtain broke all the piles with which it came in contact, being about twelve in number, of green sound oak from 14 to 16 inches in diameter.

This strong current was due not to the contraction of the water-way alone on closing the gap, nor to the increase of head from cutting off the supply to the interior space by the works above as the stage fell below the crest of the upper section of the solid training-wall, although each of these contributed its share to that result; but the main cause must be sought in changes which occurred in the reefs outside the hurdles about this time. The lower reef, which had been deeper, suddenly became the shoaler of the two, and by their convergence an immense body of water, after crossing the upper reef, was thrown against the training-wall in the form of a jet 25 feet deep and 200 feet wide, flowing with a velocity of not less than 6 feet per second.

Its power to scour the bed of the river in that vicinity was shown by the continual increase in depth throughout its entire length, and by the gradual settling of the solid wall, obstructing its path a short distance in advance of the completed hurdles in the primary line, which was being advanced as rapidly as possible to close the gap and turn this body of water from the area to be inclosed by hurdles.

After crossing the line of primary hurdles, the width of this body of deep water increased with small diminution of depth, but with less velocity, for a distance of 1,000 or 1,200 feet to the vicinity of secondary line No. 26, where it dispersed dividing into the three bodies mentioned in a preceding paragraph and shown in sketch.

As the river fell there were indications that it was concentrating in the passage-way through dike No. 4 and out below the Barracks, which caused serious fears to be entertained that so much water would be drained from the navigable channel as to render it very shoal if not impassable; but about this time a slight rise occurred which changed the lines of maximum velocity to the navigable channel again, and before the next fall could operate so as to bring the strong current to bear on the wall, the

orifice of the jet had been closed by practically connecting with the solid wall, having passed the point at which the wall commenced showing above water at the existing stage though the connection was not actually made, the primary line of hurdles passing parallel with and about 40 feet outside of the solid wall to its lower end, where it was drawn in to follow the continuation of the line of solid wall to dike No. 4.

The primary line of hurdles was completed from the upper end of the gap to its intersection with secondary line No. 26, a distance of about 4,200 feet; and, as several sections were broken and reconstructed during the season, it is estimated that the total length of primary hurdles constructed will aggregate about 6,000 feet, in which 9,000 linear feet of curtains were expended, showing that each curtain, when placed, overlapped about one-third of its length upon that previously placed.

From its intersection with secondary hurdle line No. 26 to dike No. 4, no work was done on the primary hurdles except driving the piles, on account of the working season being closed by the severe weather, which set in on the 16th of November at about the time the pile-drivers reached the lower point named. The work of finishing was retarded by several causes, the most prominent of which was the difficulty experienced in procuring laborers, large numbers of whom went South about that time, preferring to seek work there rather than here. Some delay was also caused by an unexpected falling off in the supply of brush, owing to the rains having softened the ground on Zeigler's Island, over which it had to be hauled, so that it was not practicable to keep the roads passable. This was remedied by moving the force to Saint Genevieve Towhead, where the ground was more sandy.

While the work of completing the primary line was thus delayed, the pile-driving was hurried forward in order to utilize a row of piles in preventing a large body of water from crossing its line. All these circumstances conspired to widen the space between the lower end of the line of piles and the finished work at the time that field operations for the season were closed.

The construction of secondary hurdles progressed steadily from the time that it was commenced to the close of the season. The rate of progress in deep water was variable and at times quite slow, the force employed being limited by the number of available ways upon which curtains for hurdles could be constructed, while the depths of water near the primary hurdles and between secondary lines Nos. 20 and 25 were too great to admit of wattling brush upon the piles. A maximum depth of 35 feet was found near the outer end of secondary line No. 23, while 25 to 30 feet were quite common depths over the space named. The force was also limited early in the season by the number of available piles of suitable length, being insufficient to keep all the drivers at work in this deep water. Therefore work was necessarily commenced in the shoal-water on secondary lines Nos. 28, 29, and 30 earlier than it otherwise would have been. Commencing with secondary line No. 20, the construction kept pace with that of the primary hurdles, so that each of the secondary lines was built under the protection of the primary hurdles, being completed to the intersection only after the primary line had been finished to some distance farther down stream. The current crossing the line of primary hurdles below dike No. 3 made the strict observance of this precaution a necessity in order to obtain success, it being still strong enough to destroy any hurdle line constructed with ordinary strength, intersecting its axes at a large angle, though greatly reduced from that in the same locality during the fall of 1879, or even in the spring of 1880.

In such depths even small velocities exert great force against the piles when checked to any considerable extent, the measure of which is truly indicated by the head of water raised at the obstruction. In several instances the head raised by hurdles constructed of closely woven curtains, although under the protection of the primary line, was not less than 8 inches. This, acting with a leverage due to depths ranging from 25 feet to 35 feet, tended either to break or overturn the piles, while the increased current lessened their power to resist overturning by scouring the bottom.

This led to a modification of the forms of construction by which the bottom was protected and the piles strengthened by bracing to any desired extent, which is more fully described under head of forms of construction. This modification, however, had been looked forward to as a necessity whenever the circumstances of strong current, deep water, and movable bed should combine, as they did on the last 500 feet in secondary lines Nos. 23 and 24 immediately in rear of the primary hurdle line.

Below secondary line No. 24 the currents and depths decreased so that there was no necessity to protect against scour, the ordinary forms of construction being sufficient. While above, in lines Nos. 20, 21, and 22, no protection against scour was used, still, on account of the great depths and strong currents, whenever a break in the primary line above or a rise in the river caused a considerable body of water to flow through the gap in dike No. 3, such protection would have been beneficial. Several times during the season small breaches were formed in some of the lines, and were repaired as soon afterwards as was practicable.

The season's operations on secondary hurdles consisted in repairing the breaches made during the high-water in lines Nos. 18 to 27, inclusive, in extending lines Nos.

20 to 24 to the primary hurdles, and in repairing the gaps which occurred afterwards in the lines. The piles were driven in lines Nos. 25 and 26 for their extension to the training-wall, except a small passage-way near the western edge of the bar, while curtains were placed in the former to within a distance of about 250 feet of the training-wall, except a gap of about 150 feet, including in its limits the passage-way left for the barges, quarter-boats, and other vessels pertaining to the equipment. A corresponding opening was left in each of the lines to dike No. 4, through which the vessels used in connection with the work could be passed on their way to the navigable channel.

Line No. 27 had piles driven for its extension to the training-wall, but the hurdling was not completed for a distance of about 500 feet from its outer end. In lines Nos. 28 to 30 all the work done pertains to this season's operations. In line No. 28 piles were driven from shore to a distance of 1,700 feet, or within 200 feet of the primary line, while 600 feet of hurdling was left unfinished, 400 feet of which was adjoining the primary line and 200 feet in the deep water of the channel passing east of Carroll's Island. In line No. 29 the piles were driven to a distance of about 1,000 feet from shore, which extended to the eastern edge of the sand-bar extending up from the head of Carroll's Island, while the hurdling was completed to a distance of 600 feet from shore, and the other 400 feet was in process of being wattled at the close of operations. This line was located 500 feet below No. 28, at its shore end, and its direction was perpendicular to the line of the lower section of the primary hurdles, extending from dike No. 4 to Carroll's Island. Line No. 30 was laid out 1,000 feet below and parallel to No. 29, and 100 piles were driven in it, extending the outer end of the line to a distance of 500 feet from shore.

For the location and extent of the works completed during the first half year, reference is made to sketch 8, which, as has been stated, was made from an examination after the season's operations were suspended, and upon which the completed hurdles are shown.

Work was resumed March 1, the ice in this locality having broken up on the 10th of February preceding, with a rise of 8 feet in twety-four hours.

The hurdles built during the first half of the year sustained serious damage, though less than might reasonably have been expected from such masses of ice driven by currents having the velocity due to such a rise.

When a reconnaissance was made just before resuming work, the ice floating from broken gorges above had drifted in behind the secondary hurdle lines, rendering such examination as would be necessary to determine the exact condition of all these lines impracticable; however, if the condition of the hurdles then should be considered to be that found after all of the floating ice had disappeared from this area, it would place the damage done by the breaking up of the heavy ice of the winter in the most unfavorable light possible.

After all the ice had gone, the piles in the primary hurdles were found to have been broken or overturned from its upper end to its intersection with secondary hurdle line No. 21, but the break over it showed it to be still serviceable at low stages of water above secondary line No. 19. From line No. 19 to No. 20 the damage was greater, though the shoal water inside tended to turn the direction of the currents toward parallelism with it, and the bars formed by deposits were not attacked. From line No. 21 to No. 22 the current set in strongly across the primary line and had cut a vertical face on the bar inside and was still eroding it slowly. From secondary lines Nos. 22 to 24 the piling was in good condition, and the curtains, though torn and cut by the ice, still were serviceable in checking the flow of water through them. From secondary line No. 24 to dike No. 4 but few isolated piles showed above the surface, while curtains could be seen only where the piles remained standing, but the current was nearly parallel with the line and the deposits inside were not seriously damaged.

Of the secondary lines those above No. 18 being under the protection of the training-wall, and having secured large deposits, were not exposed to attacks of ice set afloat by the breaking up of the river, but only to the movement of that which was formed in place, and they sustained that pressure with insignificant injury. Nos. 18 and 19 were each broken in the depressions on either side of the large middle bar. Nos. 20 to 29, inclusive, were broken in the old channel passing near shore. In many of these the piles were only pushed over, in others scoured or lifted out, but in all of them the damage was such that at prevailing stages there was a channel through which the flow of water was practically unchecked, causing the necessity of repairing at least enough of them to obstruct the flow and prevent the enlargement of the channel which would follow the concentration of an unobstructed current upon it. Westward of the bar, lines Nos. 20 to 29 were not seriously damaged, though possibly the passage-way left in Nos. 24 to 28 was widened in some of the lines by the piles on its sides being overturned. Later small gaps were broken through each of lines Nos. 20 and 21.

When work was resumed the gorges of ice above had broken no farther than the mouth of the Missouri, but they were breaking up under the influence of the spring weather, and higher water keeping more or less floating ice in the river here until

about the middle of March, rendering work with pile-drivers and barges in exposed situations very hazardous. On this account the work of repairing the primary line and the upper lines of secondary hurdles was not begun until the river was open to navigation far enough above to give time for removing the equipment between the receipt of a report of the breaking of a gorge and arrival of the ice at the works, which delayed these repairs until about the middle of March. In the meantime the breaches in secondary lines Nos. 27, 28, and 29 between the shore and the middle bar had been repaired.

Between this and the middle of April the primary line was reconstructed from its upper end down to a distance of 200 feet below secondary line No. 20, where work was suspended temporarily on account of the excessive depths and strong current making the driving of piles difficult and expensive. The secondary lines Nos. 18, 19, 20, 21, 24, 26, 27, and 28 having been repaired from shore to the middle bar, and No. 29 having been repaired and extended to a distance of 1,100 feet from shore, nearly all the force was transferred to the Missouri side and began the construction of secondary hurdles below the mouth of the river Des Peres, leaving a small force of laborers on the Illinois side to repair some small breaches that were made in secondary lines Nos. 18 and 19 by the heavy accumulations of drift-wood, which had lodged against them during the high stage of water.

The construction of secondary hurdles on the Missouri side was continued until about the 1st of May, when it also was temporarily suspended on account of the excessive depths due to the prevailing flood stages. During this time, lines Nos. 1 to 8, inclusive, had been extended from shore to points at which the greatest depth was found in which the maintenance of hurdles was practicable without too great expenditures in strengthening the lines by bracing or other means. With the currents due to the high and rising river, and the drift that accumulated against the lines, about 25 feet was the greatest depth in which it was found practicable to work, and was found at the following distances from shore on lines Nos. 1 and 2, each, 200 feet; Nos. 3 and 4, 300 feet; Nos. 5 and 6, each 400 feet, and No. 7, 500 feet. After the flood had subsided, further extensions were made between the 6th and 30th of June, leaving these lines at the close of the year completed to the following distances from the original shore-line: No. 1, 200 feet; No. 2, 300 feet; No. 3, 400 feet; No. 4, 500 feet; No. 5, 650 feet; Nos. 6 and 7, 800 feet each, while Nos. 8 and 9 were begun and finished 400 feet and 60 feet from shore, respectively. The hurdles built in repairs, extensions, and constructions during the year aggregate 31,500 linear feet, of which the average depth is much greater than that of those previously built, being about 23 feet, giving an area of 725,000 square feet. Of the above amount, 9,500 linear feet, or 248,000 square feet, were constructed on the primary hurdles, and the remainder on the secondary lines, of which about one-fifth was constructed on the Missouri side of the river.

The great depth of the hurdles is due in part to the deep water found in many parts of the work at low stages of river, and in part to the high stages prevailing during the second half year, work being continued until the flood reached 30 feet above low water on the Walnut street gauge, Saint Louis.

2. FORMS OF CONSTRUCTION.

When the permeable system was introduced in the spring of 1879, the knowledge of the adaptability of the various forms since used was so limited that the work had of necessity to advance step by step on a strictly tentative basis. It is true the system had been tried in this and in foreign countries with more or less success, but, so far as is known to the writer, always under conditions essentially different from those existing at Horsetail Bar, so that forms of construction suitable to any of the conditions known to exist where they were tried had to be modified to suit the conditions existing here. The adaptability of the different designs for any particular work was determined by experiment, and as might be expected some of the forms were so radically changed as to become scarcely recognizable as outgrowths of the original designs. No single form has been found suitable for the whole work.

Secondary hurdle lines Nos. 1 to 16 were built in rear of a solid wall with its elevation about the same as that of the hurdles. No special effort to brace the hurdles or to protect the bottom against scour was necessary, nor was it important that the horizontal rods of the hurdles should extend to the bottom. To check the surface current was all that was necessary in order to secure deposits. Line No. 11 was built in 23 feet of water with rods only 8-feet below the surface. This line is now covered with deposits of sand. When the work passed below the protection of the solid wall the currents were found to be considerably stronger, and to neglect to push the rods well down upon the bottom would insure the early destruction of the work by the scouring of the piles from their places.

Two general forms of hurdles have been used, one of which is called fixed hurdles, being constructed in place, the other, curtain hurdles, constructed by placing curtains against piles. In fixed hurdles the piles are driven in a single row and spaced from

5 to 6 feet between centers, and the brush is wattled directly upon them as described in the report for the year ending June 30, 1879. This form, together with arrangements for the workmen to stand while constructing them, is illustrated in Fgs. 1 to 6, Plate 10, in which Figs. 1, 2, and 3 are, respectively, plan, section, and elevation, showing a foot-bridge made by placing stage plank upon a row of piles parallel with and 2 feet from the line of hurdles, these piles being spaced about 25 feet or at any other distances less than the lengths of the stage plank. This bridge was designed in 1879, soon after the construction of hurdles was begun. The continuity of the horizontal rods is shown unbroken in these figures, which was the usual practice, but no special importance was attached to that feature. Figures 4, 5, and 6 are, respectively, plan, section, and elevation, of the same form, showing a floating platform supported by small flats upon which the workmen stand while constructing. The form of flat shown was not designed especially to support this platform, but for general use in the work. Its application to this purpose arose from sudden changes in the stages of the river during the second half of the year. To complete the description of this form two other items of detail which escaped attention in former reports may be mentioned; the upper horizontal rod is nailed to the piles to prevent the destruction of the hurdles by their buoyancy raising these rods over the tops of the piles, and the bark is stripped from that part of the piles between the surface of the water and the bed of the river to decrease friction by which the rods can be pushed to greater depths.

Forms of curtain hurdles are shown in Plates 11 and 12, in which Figs. 1 are plans, Figs. 2 are sections, and Figs. 3 are elevations, each of these elevations being shown as it would appear if viewed from the down stream side. The curtains were constructed upon movable ways carried upon barges, a type of which was shown in perspective in Fig. 9 in the report of last year.

The piles are shown driven in a single row, and spaced about 10 feet between centers. This form of piling was used only where the forces to be resisted were not great. The piles were driven singly, in pairs, in clumps of three each, or in two rows, strengthened by systems of bracing according to the necessities of any particular locality. When the piles were driven in two rows, these were connected by systems of bracing, by which both rows sustained pressure. Several methods of bracing were used experimentally and those giving satisfactory results for the least cost were selected for permanent use. Of these there are two, differing from each other only in a single detail in attaching the heel of a diagonal brace to a pile in the lower row. The second method is shown in section, plan, and front view on Plate 13, Figs. 1, 2 and 3, respectively. In Fig. 1 the diagonal brace *b* is shown in dotted lines, while in the position it occupies during the driving of the pile in the lower row to which it is attached, and the full lines show its permanent position. The brace *b* is attached to the pile *p* by double eye-bolts *i i i* passing through the brace, and *i*, through the pile, and each supplied with a nut, as shown. A shoulder is cut in the pile to receive the head of the brace, which is fastened there by drift-bolts. The piles in the upper row are finally connected together by waling pieces, and a system of ties and braces is used to connect the tops of the piles in the two rows as shown.

The first method differs from the above only in having a ring slipped over the pile *p*, instead of the bolt *i*, as shown. Cleats may be spiked to *p* to stop the ring at any desired height.

In the figures the piles are shown as if driven at equal distances in both rows, which was done when the velocities and depths were excessive. Usually the spaces in the lower row are double those in the upper, or even four times as great if those in the upper row are spaced for fixed hurdles, and changes in the systems of braces were made to correspond to these spaces.

A foot-mat to protect the bottom against scour was used when the nature of the bed and the velocity of the current was such as to indicate that such protection was necessary.

Of these forms fixed hurdles were used during the first half of the year whenever the depths of water did not exceed 10 feet, and in the second half year were extended to parts of lines having no more than 15 feet depths, curtain hurdles being used for all greater depths.

During the first half year piles were braced and driven in clumps or pairs, only when the currents and depths caused the resistance to become too great to be withstood by the piles of a single row; during the second half year, bracing the piles by one of the methods named was adopted on all lines, the choice depending upon the way in which the piles in the second row were driven. If the piles were driven by hammer alone, braces attached by eye-bolts alone become detached by the bolts breaking from the effect of the heavy blows of the hammers, but if the piles are driven by jets of water, using the hammer only to keep them in motion, no such effect need be feared. The braces attached by ring-bolts being placed after the piles have been driven, are suitable for either method of driving piles. The cost of placing braces is about the same in both methods.

Applying these governing principles to the actual work, fixed hurdles on a single row of piles were used during the first half year in repairing breaches in secondary

hurdle lines Nos. 18 and 19; in repairing lines Nos. 20 to 27, between the shore and the sand-bar, in constructing the shore end of line No. 28 and all of No. 29, and a short section of No. 26 on the west side of the bar. In all the other work done in repairing and extending secondary lines, and in the primary line, curtain hurdles were used. During the second half year the application of fixed hurdles was limited by the depth due to prevailing high stages of the river, to short sections near shore, and on the edges of sand-bars. In addition to the forms of curtains shown, curtains were made of pine lumber, after the design of the gates used in the plank training-wall in 1879, except that the sections were increased to from 32 to 40 feet, and spaces two inches wide were left between consecutive plank. One curtain 96 feet long was made of wire, with meshes 12 inches square, and was used experimentally. The deposit in front of it did not differ materially from that in the vicinity of other forms.

3. METHODS OF DRIVING PILES.

Piles were driven by two methods: first, by the hammer alone; second, by a jet of water delivered at the foot of the pile, aided by the hammer. Neither of these methods is new, both having been used for several years in various parts of the country.

The first-named has been used here since the works were begun, and is peculiar only in having the hammer permanently attached to the line instead of the usual arrangement for tripping, the height of fall being regulated at will by the master pile-driver, between zero and the height of the leads. The plant used in this method consists of a portable boiler and engine complete, 11½ feet long over all, 32 inches diameter of waist, with twenty-six tubes 3 inches in diameter, 6½ feet long; fire-box 44 inches high, 38 inches long, 26 inches wide; cylinder 8 inches diameter, 12 inches stroke, and driving pulley 48 inches diameter. Set of crab machinery, complete, having a shaft carrying a pulley 36 inches diameter, and pinion 9½ inches diameter, and another shaft carrying a spur-wheel 43 inches, and drum 13 inches in diameter. The hammer weighs 2,000 pounds and the leads are 36 feet high—all on a hull 68 feet long, 20 feet wide, and 3 feet depth of hold. Among the number of pile-drivers used, several varied more or less from these specifications. Add to the plant described in the foregoing paragraph a pump of sufficient capacity to throw a jet of water of sufficient size and force to settle a pile to the desired depth by opening a hole in advance of it, and fit such a pump with steam, exhaust suction, and stand-pipes, with hose, pipe, and reducers forming the jet, and there will result the plant used to drive piles by means of a jet of water, or of a jet in combination with a hammer.

This was done after making some preliminary experiments to determine the most suitable capacity of pump for the work.

Still the experiments were not sufficient to decide positively in favor of any one pump to the exclusion of all others. Several patterns of pumps were tried, ranging in capacity between 65 and 166 gallons per minute, each running with a piston velocity of 100 feet per minute. The capacities of the different pumps tried are shown in the following tabular statement. The Cameron, special size No. 6, was only used experimentally and was too small to give satisfactoy results. In order to drive piles to the desired depths, this pump had to be run faster than 100 feet piston velocity, or had to make more than 50 full strokes per minute, which was thought to be its safe working limit by its Saint Louis agents, consequently it was exchanged for "size 7" of the same pattern, which was used during the balance of the year.

Designations.	Diameter of steam-cylinder.	Diameter of water-cylinder.	Length of stroke.	Gallons per single stroke.	Diameter of supply-pipe.	Diameter of steam-exhaust pipe.	Diameter of suction-pipe.	Diameter of discharge-pipe.	Assumed piston velocity.	Relative discharge for assumed piston velocity.
	Inch.	*Inch.*			*Inch.*	*Inch.*	*Inch.*	*Inch.*		
Cameron Special No. 6	8	4	12	0.65	1	1½	2½	2	100	65
Cameron Special No. 7	10	5	13	1.06	1¼	2	3	2½	100	98
Worthington Duplex	7½	4½	10	1.38	1½	2	4	2½	100	166
Daton Cameron No. 6	9	5	10	0.85	1¼	2½	3	2½	100	102
Guild and Garrison No. 4	8	4½	10	0 69	1¼	1½	3	2½	100	83

Of the pumps named in the above table, all except the Guild and Garrison were tested experimentally soon after being fitted up, but during the second half-year, though all of the pumps were used, the work was of such a character that tests of their relative efficiency could not conveniently be made. These were all fitted up in about the same style, being placed in the cabin and firmly bolted to the deck, steam and exhaust pipes were adjusted, the latter discharging into the smoke-stack; a 2½-inch gas pipe connected with the discharge passed under the crab and up the ladder to the second platform, where a section 30 feet long of 2½-inch 6-ply rubber hose was connected to it, the other end of the hose was attached to a gas-pipe nipple of the same size, reduced to 1½ inches and connected to the upper end of the pipe, forming the jet which was composed of 1½-inch pipe in sections 8 to 16 feet long from this point to within 2½ feet from the lower end, where the pipe was reduced to 1 inch nozzle of that size being here placed upon it. Owing to the reductions in size between the cylinder and the nozzle, a jet working in the material composing the bed of the river was liable to become choked at any time, and if immediate relief was not found the back pressure would prove disastrous to the pump or fittings. To prevent this, safety valves were attached to the discharge pipes, which could be set to be raised at any desired pressure up to 150 pounds per square inch. The pressure of steam in the boilers never exceeded 90 pounds and was usually under 80 pounds per square inch, the proportion of which that was effective is not known, no indicator being attached-but the steam passed through 15 feet of supply pipe of sizes shown in the table, unprotected from the atmosphere between the steam dome and the cylinder.

The pressures upon the pipe, hose, and water-cylinder under the various circumstances attending the working of the jet would doubtless be interesting, but they could only be determined by an indicator. This was not attached, and the known elements are not sufficient for their determination by calculation. If nothing else was lacking, the pressure in the steam-cylinder being unknown, would prevent the obtaining of correct results in that way, but even if that was known, the fact that the nozzle might become choked, either in whole or in part, by filling with the material of the bottom would destroy confidence in calculated results, except for the ultimate result possible when the nozzle should become completely stopped. The only approximation to the pressure was obtained by raising the safety-valve when set at 150 pounds from the choking of the nozzle; at the same instant the pressure was further relieved by the parting of a hose coupling, which should have borne with safety not less than 250 pounds per square inch. Compared with this, the pressure due to any height to which the water was raised, or to which it probably would be raised, in driving piles by this method, is of little importance. In order to reduce the resistance to a minimum, changes in the direction of the stand-pipe were made by curving the gas-pipe as gently as was practicable, and the hose passed over a sheave, 20 inches in diameter, in changing the direction from the ascending to the descending branch of the jet, and for the same reason no reductions were made in the ascending branch, and it was only in consideration of difficulties which would have been presented in handling a large pipe that a reduction was made at the commencement of the descending branch. The sheave over which the hose passed was suspended from the ladder by means of stirrup bolts, and could be moved at will to any desired height, though the best results are obtainable when the point is selected so that the length of the section of hose shall be a minimum without breaking the connections. Attaching the jet to the pile formed another interesting study, those devices being most desirable which would give the best results under all circumstances for the least expenditure in labor and money. After trying several devices, this was secured by driving a small staple about 2½ feet above the lower end of the pile, through which the nozzle passed, while a strand of sisal yarn secured the pipe to the upper end of the pile. A small sheave, placed on the front of one of the leads, was used for raising the pipe which stood up by the side of that lead when not in use.

The piles were prepared for driving by sharpening the butt ends with glut points before they were placed in the water; then any desired number were moved alongside the pile-driver, whence they were taken singly by passing the log-chain attached to the pile-line around one above its center of gravity, and raising it until its point was on a level with the deck of the driver. Being steadied in this position, the staple was driven and the pipe for the jet attached. The pile was then lowered until it rested on the bottom, the pump was started, and the process of driving commenced. If the pile continued moving without hesitation, the hammer remained aloft, but if the pile stopped, as it usually did after being driven 8 or 10 feet in the gravelly bottom, the hammer was lowered and used in connection with the jet, tapping the pile lightly with about 2 feet fall, which by keeping the pile continually in motion prevented the sand from settling around it and stopping its progress. The piles were usually driven about 13 feet, and the actual time of driving was about 4 minutes each, though when the resistance was small not more than one-half of that time was required. The first 10 feet was made in much less than one-half of the whole time, frequently in less than one minute. But a more interesting question is the rate at which piles can be driven

a certain average distance, including preparation, handling, minor repairs to machinery, and all stoppages not exceeding one-half of an hour at any one time; and that rate compared with driving to the same depth in the same locality, and with all the circumstances as nearly the same as practicable, by means of the hammer alone. This is shown in the following statement covering the work of all the drivers during the time that experiments were being made. The notes given here were taken from the work actually done by all of the drivers during the months of September, October, and November:

Piles driven by hammer alone:	
Time, working hours	1,607
Number piles driven	1,692
Average depth driven, feet	12
Number piles per hour driven	1.05
Number feet per hour driven	12.6
Piles driven by jet and hammer:	
Time, working hours	220
Number piles driven	306
Average depth driven, feet	12.9
Number piles driven per hour	1.4
Number feet driven per hour	17.6

The number of piles driven per hour by the hammer, 1.05, is 75 per cent. of that driven by the jet and hammer, but the latter were driven to a greater average depth. The number of feet driven per hour by the hammer is only 72 per cent. of those driven by the jet and hammer, while the cost of the jet only adds about 15 per cent. to the cost of plant, and the current expenses were about the same for each method. The saving in cost of driving the piles does not represent the whole advantage gained in using the jet. The piles being driven butts down gives a greater sectional area at the bottom, where the strain is greatest upon piles performing the duties required in this and similar works. Further advantages of having the butts down are that the piles have a much stronger hold on the bottom and present less surface to the current.

No opportunity was presented to test the maximum depths to which piles could be driven. They were driven to any depth desired up to 18 feet, although before reaching that depth the progress became very slow. Owing to the great quantities of gravel found in this locality, the maximum depth reached here would be lower than the same plant would accomplish under more favorable circumstances. The question is, to a great extent, a local one, the same plant having different maxima in different materials, and different plants in the same material. It is safe to say, however, that whenever the ascending current fails from any cause whatever to bring the material excavated up to the surface of the river bottom, the maximum depth to which that pile can be driven by the force acting upon it has been reached. The river would fill the space around the pile with the material composing its bottom, and pack it as soon as the upward flow was checked. The causes which might conspire to bring about this result are numerous, one of the most prominent being the collection around the foot of the pile of the heavy material through which it has passed.

4. WILLOW PLANTATIONS.

Referring to the plantations of willows made under instructions dated February 23 of the last fiscal year, owing to a different construction from that intended being placed upon them, none were planted during this year prior to October. About that time a place was selected 50 feet north of secondary hurdle line No. 29, the slope there being very gradual. Groups were set out at each foot of elevation from 14 feet to 25 feet above low-water, in quincunx order, the cuttings used ranging from one-half inch to 4 inches in diameter, and were thrust into the ground from 18 to 36 inches. In order to observe their growth under as many different conditions as possible, trenches were also dug to different depths, and at all stages between 12 and 25 feet above low-water, and shoots and cuttings of different sizes were buried in them.

Other groups were planted in November a few feet south of those for October, being set out under the same conditions. Work being suspended soon after on account of the severity of the weather, this was the last group planted during the season.

These plantations were set out so late that no results could be noted in the fall, while the prevailing high stages of the river prevented any examination during the last half year.

Observations were made upon those set out in the spring, and showed that a considerable number of the larger cuttings were alive, especially those having joints or budding places set under ground. Nearly all of those set at the lower elevations were carried away by the high-water, and all of those on the main shore, near the hurdle lines, were covered by the heavy drift which lodged upon them. But few of the smaller cuttings were alive when last seen, and it seems that a size of at least 1 inch in diameter is necessary to insure growth except under the most favorable circumstances. They

require to be sunk to a depth only sufficient to protect the roots from becoming dry; for the cuttings set upon the bar where a deposit was made soon after they were planted show no greater percentage of growth than those planted upon the main shore, where no such deposit was made. This deposit does not seem to retard their growth, for though the bar upon which young willow shoots from 1½ feet to 2 feet high stood thickly in the spring was covered during the high stages of the river with a layer of mud nearly 4 feet thick, its surface was still covered with young willows, when the water subsided, and their subsequent rapid growth, they being about 6 feet high at the close of the season, would indicate that they were the same plants. These same willows reappeared upon the bar in full vigor after the flood of this year, though the deposit was about equal to their height.

Willows are springing up thickly on nearly all the bars which have become dry since the summer flood.

5. PROGRESS MADE TOWARD COMPLETING THE IMPROVEMENT.

The progress made toward completing the work of improving this locality is shown in the deposits made over the areas to be reclaimed and in the improved direction, width, and depth of the navigable channel.

Referring to sketch 9, from surveys made soon after the close of the year, when the river was at a 21-foot stage, and reducing to the same stage with the other sketches, the condition of the works, the location of the navigable and other channels are shown, and comparing this sketch with sketch 6 renders evident the substantial progress made during the year towards completing the improvement.

The area to be reclaimed has had large deposits made over it, not evenly distributed, however, the bars which had considerable elevation before having received heavier deposits this year than were made in the depressions.

That extending across dike No. 2, down to secondary hurdle line No. 27, has been raised to 25 feet above low-water near its upper end, depresses to 18 feet below dike No. 3, and raises to 30 feet above low-water between secondary lines Nos. 24 and 26.

That from secondary line No 28, with its crest 21 feet above low-water at secondary line No. 29, raises to about 23 feet just above the head of the island. Comparing this sketch with sketch 6 shows large accretions made during the year, but, as stated in the introduction and shown in the sketch 7, not all due to work done this year. An estimate of the quantity of material deposited in the areas inclosed by the hurdles, together with that which it is proposed to inclose, or at least which is affected by the hurdles, extending from the head of Carroll's Island to the upper end of the training, wall, bounded on the west by the line of primary hurdles on the Illinois side, and on the Missouri side the area above dike No. 1, bounded on the east by a line drawn through the outer ends of the secondary hurdle lines as they existed at the close of the year. This estimate aggregates 353,047,774 cubic feet, or in round numbers 13,000,000 cubic yards of material, of which 500,000 cubic yards were deposited on the Missouri side since the 12th of April of this year, and is distributed over about 40 acres, and 12,500,000 cubic yards were deposited on the Illinois side over an area of about 800 acres since the spring of 1879. If these deposits had been evenly distributed they would have raised the whole surface on the Illinois side about 10 feet.

On the Missouri side the deposits were very regularly distributed; extending from the shore they raised the bottom about 10 feet on a zone 100 feet wide at the mouth of the river Des Peres, and 300 feet wide at dike No. 1; from this zone the deposit depresses to become zero at the out-ends of the secondary hurdles completed during the year. This latter zone was influenced only by the hurdles constructed during the month of June. While the improvement in the navigable channel is progressing steadily and the bed on the reefs has generally remained stationary during high and low stages, having 4 feet depth in the winter with 4 feet stage in the river and 31 feet when that stage was reached during the flood, still a trace of a reef was developed after the flood had subsided to about 18 feet; a second flood brought the stage back to 25 feet above low-water, but the same trace can still be detected about 15 feet under water and extending from the vicinity of dike No. 1, through the old middle bar in front of Jefferson Barracks, then joins the bar shown below, and leaving the lower end of that bar, extends to the large bar above the head of Carroll's Island. A channel passing down by the training wall to dike No. 4, thence in the direction of quarantine, rejoins the navigable channel by turning to the right at about one-half the distance, and attaching importance to the reef by crossing it with a depth equal to that of the navigable channel, and at an elevation less by the fall in about 2 miles of the river. This channel was developed in the early spring when by strong currents it was so well marked that it did not require a pilot's experienced eye to detect it. The depths have frequently been, as now, equal to that in the navigable channel. The current now is so slack that experienced pilots did not discover it until soundings obtained in making sections of the river in that vicinity indicated that it still existed. This, taken in connection with the influence that the works in process of construction on the west side

of the river may exert in opening a channel through the reef near dike No. 1, encourages the hope that the navigable channel may continue in the position shown during the coming low-water season, and that it will open then permanently.

II.—CONSTRUCTING AND REPAIRING EQUIPMENT.

In addition to considerable repairs, including the construction of a new hull for pile driver No. 1, the equipment was increased by the construction of quarter-boats Nos. 6 and 7, eleven portable shanties for kitchens, mess-rooms, and quarters, three model barges, Nos. 25, 26, and 27, pile-drivers Nos. 6 to 10, and by the purchase of twenty-seven barge flats, Nos. 28 to 54.

Of these the hull of pile-driver No. 1, quarter-boats Nos. 6 and 7, and pile-driver No. 6 were built during the first half year. The hull of pile-driver No. 1 was built first, having been begun the first of September and finished early in October. Pile-driver No. 6 was built during the month of October. The hulls of each of these drivers were built upon the same plan, which followed the general design of the hulls of pile-drivers Nos. 1 to 5, making only such changes as experience had shown to be beneficial. These hulls were 68 feet long, by 20 wide, by 41 inches gunwale depth, with two gunwale bulkheads running fore and aft under the boiler and machinery. A Worthington "Duplex" No. 5 pump was attached to each, fitted with gas-pipe and hose necessary to deliver a jet of water at the foot of the pile, in addition to the hammer and the machinery needed to run it. The leads on each of these drivers were 45 feet high, to make them suitable for handling and driving long piles in deep water.

Quarter-boats Nos. 6 and 7 were begun during the latter part of September, and completed ready for service about the 10th and 20th of October, respectively. They were constructed from plans of quarter-boats Nos. 4 and 5, and their hulls are 112 feet long by 20 feet breadth of beam and 3½ feet gunwale depth, with a guard 2 feet wide on each side and astern. Their cabins are 90 feet long by 20 feet wide, with skylights and ventilators, divided into rooms suitable for mess-room, kitchen, and bed-rooms for a boarding master and his help, an overseer, foreman and 48 laborers, with the tables, bunks, and benches sufficient to accommodate these persons. The hulls, with the exception of the timber heads and rake timbers and the cabins, are of pine, all finished in a substantial manner.

Late in the fall season the construction of three model barges, Nos. 25, 26, and 27, was begun. These were designed after the model and specifications of barges Nos. 17 to 20, inclusive, though differing from them in some of the details. This model and specification was selected after using the barges five years with entire satisfaction, and with no considerable expense for repairs.

Their lengths are 135 feet over all, breadth of beam 28 feet, and depth of hold 5½ feet; modeled 37 feet 8 inches fore and aft, and having full lines. They have about 115 feet available length for a deck load, and are built substantially, only the best material being used, and the workmanship being as nearly perfect as it was practicable to obtain. They were completed and put into service March 15, April 1 and 25, respectively.

Work was begun upon pile-driver No. 7 about the 1st of April, and about the 20th o the same month on fourteen new pile-drivers—Nos. 8 to 21—and on a new hull for No. 2 These new drivers were of the same designs as No. 6, except that the height of the leads was reduced to 36 feet. Of these drivers, Nos. 7, 8, 9, and 10 were completed before the close of the year, being made ready for service about the 8th, 15th, 25th, and 30th of June, respectively.

Additional material and machinery had also been received for Nos. 11 to 16, including the pumps and crab machinery for all. Nos. 11 to 14 were advanced nearly to completion, and work was begun on parts of nearly all the others.

The twenty-seven barge-flats recently purchased had arrived. Material to be used in the repairs and alterations necessary to adapt them to the purposes for which they are intended, in connection with improving the river, had been ordered, some of it received, and the work of altering and repairing some of them was begun.

Eleven portable shanties for quarters were built during the second half year. These were divided into four sets, a set comprising one shanty for kitchen and mess-room, one for quarters for laborers, and one for office and quarters for assistants, except that one of the sets has tents in place of the shanty for quartering laborers. These shanties are all built in sections, which are fastened together with screw-bolts and can readily be taken apart and set up again whenever a necessity of moving may arise.

The shanties for kitchens and mess-rooms are each 60 feet long by 20 feet wide, with walls 8 feet high, divided into kitchen, mess-room, and store-room, from which a small room can be curtained off to serve as quarters for help. The shanties for quartering laborers are each 45 feet long by 20 feet wide, with 8-foot walls. The assistants' offices and quarters are 30 feet long by 16 feet wide, and with same height as preceding. All these shanties have steep roofs made of matched boards covered with canvas, and painted; the balance of the lumber, except the floors, being common. They are built

in sections 15 feet long. Other shanties will be added, and they, together with pile-drivers under process and the barge-flats undergoing repairs and alterations, will be ready to enter service as part of the available equipment for use in the operations of the approaching fall season.

Material had been ordered, of which a part had been received, for the construction of an hydraulic excavator and two hulls for ways for mattresses; but of this material not enough had been delivered to begin the construction of either the hulls or the excavator.

In addition to the work mentioned, ordinary repairs were made upon steamboats, pile-drivers, barges, and quarter-boats, and the necessary additions were made to the stock of small boats, to increase their number to that needed by the force, which can profitably be employed with the increased equipment.

The work pertaining to the construction and repairs of equipment has progressed slower than it should, but the delays originated in causes which could not, under the circumstances, be anticipated, and therefore no provision could be make to avoid them. The causes of the delay were that the lumber needed for such work is not kept in stock by lumber dealers here, nor are suitable logs kept from which it can be cut on order. Then follow the delays incident to cutting, hauling, and rafting logs to the mill, procuring cars from railroads taxed to their full capacity with business which will bear a more profitable freight rate, and even after cars have been furnished, loaded, and started to their destination they are frequently side-tracked, to wait until the road has been cleared of its blockade of freight. In addition, this has been a year of activity in all branches of the lumber business in this vicinity, mill-owners and general dealers having as many orders, each in his special line, as he could fill.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Capt. O. H. ERNST,
Corps of Engineers, U. S. A.

F.

REPORT OF MR. MAX E. SCHMIDT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 11, 1881.

SIR: In compliance with paragraph 58 of the regulations, I have the honor to submit herewith a report covering the operations of the fall season of 1880 at Kaskaskia Bend and at Cairo, Ill.:

I. KASKASKIA BEND.

1. HISTORY OF THE WORK.

The history of the shore protection at Kaskaskia, brought down to the day when operations were resumed at the beginning of the present season, may be briefly recounted as follows:

* * * * * * *

The first appropriation ($5,000) was set apart in the act of August 14, 1876, but did not become available until April 19, 1877.

In the fall of that year this amount was applied in placing a brush and stone footing along 1,100 feet of the bank, near the head of the active caving.

This entire work was carried away in the spring of the following year, 1878. By acts of June 18, 1878, and March 3, 1879, $18,000 became available for the following two years, which sum, by allotments, was subsequently increased to $55,000.

A considerable amount of work was executed with those funds, covering three working seasons, namely: fall, 1878; spring, 1879; and July and fall, 1879.

In the fall of 1878, 2,725 feet of shore-line were protected by driving piles in the water and building a brush mat 45 to 60 feet wide, which was held in place by the piles, then loaded with stone and sunk. The inner edge of this mattress rested at about 10 feet above low-water, and was well secured by riprap.

In the spring of 1879 the stone facing was carried up to about 20 feet above low-water on the 2,725 feet of shore already protected, and 1,700 feet of additional shore-line were treated and completed as it advanced.

In July and fall, 1879, the work consisted in making brush rafts 50 feet in width, and sinking them *outside* of those sunk the year before.

In this manner 2,390 feet of shore-line received a double width of brush footing, while 1,255 feet were protected by a single width of mattress; 390 feet of brush raft were sunk in two parts, at places that seemed exposed, and a stone revetment without brush footing was extended about 760 feet beyond.

In the sketch which is herewith submitted, Plate 14, the work done in different years is represented in different colors. Thus, the work done in the fall of 1878 is shown in green,* that of spring 1879 in red,* that of July and fall 1879 in blue,* while the work of the present year (fall 1880) is shown in black.*

For a better understanding, 100-foot stations have been laid out on the surveyed line which follows the shore, beginning with zero at the upper end of the bend. The succeeding stations will be referred to in this report.

The work, which was built in 1877 and lost in the spring of 1878, appears approximately located in broken lines on the sketch.

* * * * * * *

An examination of the entire bend was made on September 24, and soundings taken to ascertain the position of the mattress placed in the previous year; but owing to the great depth and strong current, the examination under water cannot be regarded as very reliable. Mattress or brush could not be distinguished, even at moderate depths, with poles rammed down several feet through the mud. It is evident, then, that these mattresses have either been displaced by scour, or are covered with mud many feet deep. The stone revetment above water was carefully examined, and its present condition compared with the records. The result of this examination may be briefly summed up as follows:

Stone entirely gone between Stations 2 and 10, 12 and 16, at Station 20, and Station 25, and between Stations 57, and 61 + 50.

Stone partially gone between Stations 20 and 25.

* * * * * * *

The shore line was found to have caved largely at two places, located respectively between Stations 12 and 17, and between Stations 42 and 45.

In the first-named place access was difficult by a great number of trees which had fallen into the river close to the shore. In both places the caving had assumed a semi-circular shape, which was especially well delineated at the lower place. A sketch of it, and a description of the novel method by which the break was repaired, will be given further on.

It may be stated that a similar caving, only smaller in dimensions, occurred on November 29, the day before I left the work. It is located between Stations 49 and 51, and the brush footing placed here in the spring of 1879 did not prevent it.

The break was caused by the extreme low water, the bank being unable to sustain its own weight after the pressure of the water had been withdrawn.

3. *Description of the work at Kaskaskia during the fall season of* 1880.

The work done at Kaskaskia this fall may be divided into three parts:

a—The direct protection of the bank by mattress work.

b—The construction of a permeable dike at the head of the bend.

c—Repairs of breaks and recent cavings.

a. Direct protection of the bank by mattress work.

This work was to consist of two parts, viz, a continuous mattress below the surface of the water, and a brush protection above.

Your instructions regarding the work above water were given under the supposition that the continuous mattress would reach the lower end of the stone revetment before the end of the season, in which event, it was the intention to abandon the plan of the heavy revetment, and prepare the bank for the reception of a brush protection.

Unfortunately the weather was so severe that the working season did not last quite two months, and the customary tide of emigration to the South on the part of the laborers set in so early this year, that even with the advance of wages from 14 cents to 16 cents per hour, which you allowed, I was unable to retain a sufficient force to make fair progress with the work.

In total, there have been built and sunk 1,015 feet of mattress, extending from Station 30 + 90, the lower end of last year's work, to Station 40 + 95.

This mattress was not built in one continuous raft, but constructed in two sections 750 and 265 feet long.

In sinking they were allowed to overlap 10 feet, thus making the raft practically continuous.

A brief description of the proceedings will explain why I was compelled to abandon the original plan.

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* The signs used have been altered. See legend upon map.

For the construction of the mattress floating ways had been provided. These were placed in position across the channel at Station 30+90 on Monday, October 4, the incline facing up stream.

The pile-driver had driven for two days previous guide-piles which followed the shore, and were placed 40 feet from center to center. To find the correct position for these piles the foot of the stone revetment was ascertained first by soundings and the pile-driver then centered over a point about 15 feet up on the slope. In this manner the mattress when sunk against the piles would overlap the revetment and prevent further undermining or subsidence.

Construction of the mattress was begun on October 4; it was built in two layers of brush, breaking joints.

The first launch occupied two days, the delay being caused by difficulties experienced in moving the brush over the strap-iron covering the skids.

As it was necessary to use blocks the mattress was badly torn and twisted before reaching the water. Being too weak to resist the current it "doubled up" and hung with the current under the ways. Some of the head-lines parted, causing additional delay, but no loss of property. It should be stated that the current was very swift and powerful.

By some irregularities in the shore-line above, it was deflected with great violence toward the point where the work was to start. It became evident, therefore, that in order to secure success additional measures of precaution would have to be resorted to. The mattress itself was strengthened by putting in three instead of two layers of willows. A barge partly loaded with piles was dropped down by hand from the upper part of the bend and swung across the channel just above the head of the mattress. This had the effect of checking the surface current a little, and lines were at once put out connecting the head of the mattress with the posts and kevels of the barge.

As soon as practicable the strap iron covering the skids was taken off and replaced by oak strips 4 inches wide and 3 inches high, beveled on top.

Moreover, the steamer Anita reported at about this time, October 15, and aided much in the work. Nevertheless, up to October 23, only 206 linear feet of mattress had been launched. A change in overseers took place on that day, and between October 23 and November 4, 544 feet were launched, making a total of 750 feet since the start.

It will be seen that no part of the work was lost, although the head of the mattress was a constant source of trouble and apprehension during construction. With a raft 750 feet long hanging to it, the strain on the head-lines increased so much that the upper end of the mattress for a distance of over 200 feet was drawn under water by the efforts of the current to carry the whole raft away.

Under these conditions it was deemed best to make preparations for sinking at once. The mattress was cut off at 750 feet, and the original plan to construct a continuous mattress was thus obviously set aside.

It may be stated here, that the method so successfully tried on the Missouri, near Glasgow, of sinking a continuous mattress by first immersing the head of it, and securing it on the bottom, is not practicable at Kaskaskia. At Glasgow the work was done in a feeble current, at moderate depths, and the conditions were in other respects different from those existing at Kaskaskia.

The raft was sunk on the 5th of November, in the following manner:

Workmen were stationed along the shore, at places where the rock was filled up unnecessarily thick in previous years, and ordered to carry the same on the mattress, scattering it over the part next to the bank. At the same time, the side next to the channel received stone from two barges, which were dropped down from the breakwater barge above.

A large quantity of stone was thus evenly distributed over the whole mattress before it received the additional amount to sink it. This was put on the lower end first, a barge being pushed by the steamboat up and over the mattress as it sunk. The strain on the head-lines gradually increased, and the mattress was actually forced up stream before it reached the bottom.

The head of the mattress was secured in its new place, by a large amount of stone thrown off quickly when the last willow branch disappeared below the surface. The sounding-lead was frequently applied to ascertain the position of the mattress.

Preparations for a new start were made at once, in which the disposition of lines and their attachments were somewhat altered. A sketch of these attachments is submitted on Plate No. 15.

It will be seen that the head of the mattress is nearly lifted out of water by short 1-inch lines, the bite of which is worked into the mattress, 6 feet from the end. One end of these lines is made fast to a horizontal pile held against the stanchions of the barge.

The running end is only temporarily fastened, and "let go" when the head of the mattress disappears below the surface. At the same time, four 1½-inch head-lines

(drawn in red) are attached to the mattress by four toggles (T, T, T, T), and led under the barge to anchorage ashore. Trip lines of three-quarter-inch diameter lead from the toggles to the deck of the barge, and serve to haul the head-lines home, through the mattress, after sinking.

In this manner the head of the mattress was well preserved, and all the lines used in sinking were recovered. A fine raft of mattress, 255 feet long, was built between November 11 and 19.

Ice commenced to form near shore on November 14, and on the 18th, it was running in the river.

The raft was sunk on November 19, with the usual difficulties attending such work when it is undertaken with a small force, and the thermometer near zero.

* * * * * * *

b. The construction of a permeable dike at the head of the bend.

An examination was made of the site of the proposed dike on the day after my arrival, September 24, and the driver located at the foot of Saint Genevieve Island.

The location of the dike is shown on the plan on Plate 14. The dike is 1,140 feet long, and built in three parts:

1st. A shore wing, 200 feet long, built of brush and stone, and covering that part of the ground where, at a 10-foot stage (Saint Louis directrix) the driver could not work to advantage.

The two little flats belonging to the outfit were put into service, and the willows built into mattresses 12 feet wide, direct over the place on which they were to be sunk. Stone was afterward transported in the same flats, and the mattress secured in place.

Connecting with the shore-wing there is:

2d. A center part, 560 feet long, built of piles and willow hurdling.

The piles were driven 5 feet apart, and stripped of bark from the water surface to the bottom. Bridge or bench piles were driven below the main row, 25 feet between centers, for a plank way, and the hurdling done in the exact manner employed at Horsetail Bar.

Care was taken to only put down one layer of willows at a time, as it seemed difficult to ram a larger quantity of brush in place with the forks provided for that purpose. Two platforms for willows were also built below the line of hurdling, in order to dispense with the service of a barge. The average depth in which the hurdling was placed did not exceed 10 feet, and the bottom was generally soft. The brush weaving was carried up to about 4 feet above the 10-foot stage.

Connecting with the center part follows:

3d. The channel wing, a curtain dike 380 feet long, of which the piling and foundation alone were in place, when operations were suspended for the season.

As the piling represents some new features, it will be briefly described, and attention is invited to the sketch on Plate 16. Two rows of piles were driven, one in the alignment of the dike and the other parallel with it, 20 to 22 feet below. The piles in the front row were placed 10 feet and those in the back row 20 feet between centers.

Another pile, from 40 to 50 feet long, was used as a waling streak, and bolted with 1-inch bolts to the down-stream side of the upper row, about 18 inches above the water. A foundation mattress was now constructed between the two rows of piles, projecting 10 feet above the upper and 5 feet beyond the lower row.

A floating frame of stout willow poles was constructed first, and tightly lashed in the joints. The up-stream edge of this frame was held suspended above water by ropes attached to the waling streak, and the lower end allowed to float with the current. Two layers of willows were then put on the frame, care being taken to pack them well round the piles. When ready to sink the ropes at the head were cut and the mattress was guided to the bottom by the piles, and long lines fastened to anchorage above. After placiug the foundation, which was built in sections of about 100 feet, the two rows of piles were braced as follows: (See Plate 16.)

A round oak or sycamore pile, 50 feet long (called sill pile), was held in a horizontal position above water on two small flats, about midway between the two rows. Two brace or diagonal piles, 30–32 feet long, were then placed with their heads resting on the waling streak, 20 feet from center to center, and secured by iron stirrups at right angles to the sill pile.

The stirrups which held the piles together were forged of three-eighth inch flat iron, 2½ inches wide. They were led around the horizontal pile in a short groove cut into the wood to prevent sliding. The legs, or clamps, were 24 inches long, and provided with holes for the bolts, which held the stirrups to the foot of the brace pile. When thus prepared the sill pile was lifted off the flats and allowed to sink to the bottom, with the two braces attached to it. Cottonwood had to be forced down with hurdling-forks when serving as sill piles. In the completed brace the sill pile rested on the foundation mattress, and against the up-stream side of the lower row of piles.

The upper end of the brace piles was bolted alternately to a corresponding pile in the front row. In this manner a substantial combination of pile-bracing was obtained, to be tried under the pressure of curtains.

The depth of water in which this piling was placed ranged from 10 to 27 feet.

* * * * * * *

c. Repairs of breaks and recent cavings.

No stone was replaced this season, except a small quantity—say 50 cubic yards—near station 56. The repairs were confined to the restoration of the old shore line, in places where caving had occurred.

The two circular caves between stations 12 and 17, and stations 42 and 45, already referred to, were treated in the manner illustrated on Plate 17. The gap between the upper stations was, however, not quite closed when operations were suspended for the season.

A brief description of the plan adopted is given herewith.

The main row of guide piles mentioned before as being auxiliary, in the construction of the continuous mattress, was driven past the opening without attempting to follow the sharp curvature of the shore. A row of piling 6 feet between centers* for hurdling was then driven between the spurs S and S′, and bench piles 25 feet between centers were placed inside of this row. A foundation mattress, 35 feet wide, was next constructed on the water, between the hurdle and main row of piles, overlapping the inside row 5 feet, to serve as an apron against scour from over-fall.

Hurdling was commenced as soon as the foundation was sunk, and carried to a height of 4 feet above water.

The depths in the line of hurdling on the foundation mattress ranged from 0, to 16 feet. No difficulty was experienced in placing the hurdling at that depth with long poles attached to the hurdling-forks. The two deepest holes were quite narrow, with a ridge in the middle, caused by the eddy current that entered the cave at the lower and left it at the upper end.

The hurdling after being finished began to show its effectiveness at once, by accumulations of deposits in the space intervening between the hurdling and the shore. If the continuous mattress had reached station 45, it would have added materially to the permanency of the improvement.

* * * * * * *

Before closing the report of the Kaskaskia work, I beg to express here my thanks to Mr. A. F. Freis, clerk and assistant, for the zeal and interest shown in the work; * * * also to Captain Chapman, of the steamer Anita, for the aid he has given.

Much credit is due Mr. Chancey Hoadley, overseer, for his energy and efficiency in training and governing the men.

* * * * * * *

I have the honor to be, very respectfully, your obedient servant,

MAX E. SCHMIDT,
Assistant Engineer.

Capt O. H. ERNST,
Corps of Engineers, U. S. A.

G.

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., February 11, 1881.

SIR: I have the honor to submit herewith a report of the operations for the repair of the works near Cairo, Ill., during the months of October and November, 1880.

Having arrived with plant and material at the site of the work October 16, a careful examination of the protection was made.

There were found only a few breaks near the upper part of the works, and these were due, not the caving of the banks from abrasion by the river current, but to their sliding out, caused by the percolation of water, from surface pools, through the upper strata.

It was decided to grade those portions of the bank requiring the repairs, and before

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* The space between the piles was changed from 5 to 6 feet, in order to utilize willows of larger dimensions. Small and pliable willows were not often found on the barges.

placing the revetment to construct there temporary ways, upon which to build and from which to launch the mattresses which were to protect the submerged portions of the bank from scour.

These ways were built of large poles, or brush, the lower binders running parallel with the river, and serving to raise the skids, which crossed them at right angles, above the ground, as well as to hold them firmly in place, the two being lashed together with sisal yarn at every crossing. The grillage thus formed was laid in 8 foot squares. The mattresses built on these ways consisted of a top and bottom grillage, with spaces 5 or 6 feet square, inclosing two heavy courses of brush, and the whole bound through with sisal yarn. Around the edge, and at a number of points within the mattress, to increase its strength, sisal rope one-half inch diameter, was used, instead of the yarn.

In this manner there were built 274 feet of mattress, averaging 75 feet in width, in three sections; two sections were 100 feet in length each, and one was 74 feet.

These mattresses extended on the bank from a point opposite station 118 of Mr. True's survey (see sketch accompanying report), down stream a distance equal to their combined length.

On November 2, a barge having been swung across the channel a little above the head of the mattrasses, the steamer Anita launched them off the ways, one by one. They were then lashed together and made fast to the barge above. Two lines led from the head of the raft, and being carried under the barge were secured to an anchorage on the bank some distance above.

These lines were to hold the raft in position as it sank, the lines attached to the barge being slacked away. Stone having been thrown on the raft sufficient to sink it beneath the surface, the steamer Anita pushed a stone barge up over the center of the raft, and the stone was thrown off on each side, sinking the mattresses to the bottom of the river and securing them in their position.

The lower end of the raft having been somewhat torn in launching was not strong enough to resist the current and weight of stone combined, and, being broken off while sinking, was lost.

At the other points requiring protection it was found by sounding that the old revetment had not been entirely destroyed, but carried out a distance from 25 to 40 feet by the slide in the bank, so that it was only necessary to place a mattress of sufficient width to reach from the inner edge of the old stone work to the bank. (See sketch showing cross-section of such break, with mattress placed, &c.)

These mattrasses were built in place, one edge resting against the bank and the other supported on the brush barge, until sufficient brush had been placed on the frame-work to make the mattresses buoyant enough to support men while at work on them. They were then dropped in the water and finished while floating.

One of these mattresses, 140 by 40 feet, was placed at the bank between points opposite Stations 108+50 and 110. Two more, 40 by 35 feet and 45 by 35 feet, respectively, were placed between Stations 101 and 102, with a spur of the old revetment, 15 feet wide, between them. This spur was afterwards graded away, and the stone in it was used to sink the mattresses on either side.

Similar mattresses were placed between Stations 136 and 136+50, and 136+50 and 137+50, and in size 40 by 40 feet, and 100 by 40 feet, respectively.

The grade on the bank behind all the mattresses, except those between Stations 101 and 102, was restored.

The revetment was restored for an aggregate length 1,137 feet, with an average width 26 feet, and distributed between Stations 110 and 118, and 137 and 141.

Revetment would have been placed on graded bank between Stations 108+50 and 110, and both grade and revetment restored between Stations 101 and 102, had not the cold weather compelled a suspension of operations, which took place November 21, in accordance with instructions received from Captain Ernst, and contained in his letter and telegram of November 19.

The completion of those unfinished portions of the work, together with the planting of willows, in the manner described in a letter received from Captain Ernst and dated October 5, is all that remains to be done near Cairo in the spring.

The following are the amounts of material used:

Brush, constructing mattress	cords..		611.38
Sisal yarn, constructing mattress	pounds..		552.88
Sisal rope, one-half inch diameter, constructing mattress	do....		513.00
Manila rope, one-half inch, sinking mattress	do....		61.00
Stone, sinking mattress	cubic yards..	305.94	
Stone, restoring revetment	cubic yards..	1,075.47	
			1,381.41

Very respectfully, your obedient servant,

WM. S. MITCHELL,
Assistant Engineer.

Mr. MAX E. SCHMIDT,
Assistant Engineer.

H.

REPORT OF MR. PRESTON C. F. WEST, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *June* 24, 1881.

SIR: I have the honor to present the following description of the methods of field work adopted for the special surveys of the Mississippi River at Alton, Sainte Genevieve, Cape Girardeau, and between the River Des Peres and White Sand Depot.

The data available were the latitudes and departures of points of a triangulation executed several years ago, and the "descriptions of stations," the latter being so meager as to be almost useless for the purpose intended.

Only such triangulation points as were marked by holes drilled in rock were in existence; those marked by posts on the river bank, or on sand-bars (by far the greater number), had been washed away or covered up by the action of the river.

The topography adjacent to the river banks, and the hydrographical cross-sections, 500 feet apart, were required.

The river averaging less than a mile in width, and not being very tortuous, it admitted of projections being made on a scale of $\frac{1}{5000}$, sufficiently long to cover 8 or 10 miles of river; so the plane-table was chosen as the instrument with which to make the topographical surveys, and, in connection with a transit, for the hydrography also.

The party consisted of one assistant engineer, one transit man, one recorder, one steersman, one steam-engineer, one leadsman, four laborers, one cook.

The steam-launch Hornet, quarter-boat No. 2 and two skiffs, comprised the main outfit.

Care was taken in making the projections to include a sufficient number of triangulation points, believed to be in existence, from which a plane-table triangulation was made, extending the length of the survey, and during the execution of which, by the use of the plane-table, some of the old points were found, which would have occasioned much delay to have discovered in any other manner.

While surveying the shore-line on each side of the river, hydrographical stations were staked about 500 feet apart, and their positions determined on the chart.

A water-gauge was located at the quarter-boat and connected by level with the nearest bench mark of a previous survey.

When ready for sounding, every one is assigned to his post; the assistant engineer takes up a position with the plane-table, the cross-section ranges having been drawn on the chart; the transit man also takes a position, which is determined on the chart; the recorder, steersman, steam-engineer, and leadsman, on the Hornet. The two men who had driven the hydrographical stakes were each provided with a signal-pole, 12 feet long, attached to which were two white lozenges (20-inch sides), one about 7 feet above the other; they were stationed at the ends of the same cross-section. Two skiffmen, with a small boat, were convenient to the plane-table, to move it or the transit when needed. The cook recorded the readings of the water-gauge at the quarter-boat; the Hornet steams up into range on the cross-section to be sounded, and one whistle announces that she has started; at every sounding a flag is made to rise and fall over the pilot-house, directly alongside of which stands the leadsman, and in front is seated the recorder, who controls the flag and records the sounding; in midstream the flag is raised twice in rapid succession, which is noted as a double-flag by the assistant engineer at the plane-table, the transit man, and the recorder, for the purpose of a check; the flagman, toward whom the Hornet is steered, keeps the steersman in range, or, rather, notifies him when he is out of it by leaning his lozenge-pole up or down stream, signifying which way he is to go to get the range. Sometimes the steersman picks up a range of his own with the flag and some distant object, but frequently the shore is directly under high bluffs, where none other could be secured except in the manner devised. A whistle announces the completion of the line, when the flagman and the Hornet move to the next cross-section; new positions are occupied by the plane-table or transit, or both, when the cross-sections intervening between their previous stations are sounded.

Having had considerable experience with the plane-table, I soon acquired the requisite skill to make the intersections on the flag range with the alidade, and I afterwards made this comparatively easy by sticking a needle in the chart and table through the point occupied, thus calling into play delicacy of touch to relieve the eye of the double duty it would otherwise have to perform.

When the opportunity offered, the angles taken with the transit were plotted on the plane-table sheet, and the intersections of these lines with those already drawn on the chart being on or near the range, determined the locations of the soundings.

The surveys made develop the fact that the steersman can keep his range so well, in high or low water, that a simple plane-table intersection on a range line, where the angles made are not less than 25 degrees, locates the sounding as well for the purposes of the survey as the additional use of the transit.

It is a matter of regret that the plane-table is not more generally used in surveys; the reason that seems to me to prevent its general adoption is the fact that it is an awkward instrument to use at first, and requires time and patience to get accustomed to it; it is too often condemned because it cannot be handled at first with the same ease the use of other instruments is acquired.

Very respectfully, your obedient servant,

PRESTON C. F. WEST,
Assistant Engineer.

Capt. O. H. ERNST,
Corps of Engineers, U. S. A.

IMPROVEMENT OF THE MISSISSIPPI RIVER, IN THE VICINITY OF PIASA ISLAND.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., August 26, 1880.

GENERAL: I have the honor to transmit herewith a map of the Mississippi River,* in the vicinity of Piasa Island, constructed from surveys made in May and June last, under the authority contained in your letter of April 27, 1880.

This locality has long been the subject of complaint from steamboatmen. A brief examination was sufficient to show that the works required for a radical improvement of the entire stretch covered by the map would be extensive and costly. The funds available, about $35,000, are sufficient only for beginning. While this amount will not go very far, it should be applied so as to form part of a general scheme. I have therefore thought it worth while to survey and study the entire stretch, and to present in outline a general plan for its improvement. The changes in the bed are less rapid and less radical in this part of the Mississippi than they are below the mouth of the Missouri, and while it may be necessary to change the exact location of some of the works before the time arrives when funds will be available for their execution, it is thought that the general features of the plan may remain the same for a considerable period.

The width of the river is from three-quarters of a mile to a mile, the channel winding in sharp curves, touching alternately one bank and then the other. In one case the distance measured on the axis of the stream between two such points of contact is little more than half the width of the river. The depth of water upon the crossings is liable to become as little as 30 inches. About the middle of the stretch covered by the map is Piasa Island, which divides the river into two chutes. The channel was formerly sometimes in one chute and sometimes in the other. As the first step in the improvement, it was decided by my predecessor, Col. James H. Simpson, Corps of Engineers, to close one of these chutes, and he selected for that purpose the southerly one, or the one between the island and the Missouri shore. A submergible dam, E F, was built here in 1875–'76 and '77. The selection of this chute was not preceded by a proper study of the locality. It is found that a continuous ledge of rock extends from the head of the island to the Illinois shore, so that the effect of confining the water to the northerly chute is to create a rapid current without an adequate increase of depth. The location of this ledge with reference to the normal low-water level is shown upon the sections A B and C D. The distance of the ledge below that level is at one point only 0.2 of a foot. There is usually a greater depth of

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* Not printed; too large for insertion in annual report.

water than this at the lowest stage, owing to the damming effect of the ledge, but it is often as little as 30 inches over the entire width of the channel. One object of the survey was to ascertain the extent of this ledge, and whether the evil could be remedied without removing the dam. Frequent borings into the bed were made until it became apparent that the amount of rock excavation required to give a 6-foot channel would be so great that it would be far more economical to remove a portion of the present dam and close the other chute. As soon as this was ascertained orders were given to extend the hydrography down as far as Hop Hollow, with a view to ascertaining what kind of a bed existed for the reception of the channel with its new approach. The map covers a total distance of about $6\frac{3}{4}$ miles.

The present location of the channel is shown by a broken and dotted black line. It is the natural line for the channel, and should be adhered to as far as practicable. It is plain that large bodies of water are spilled over and wasted, pursuing with diminished velocity a shorter course down the river. The problem is to collect this waste water and throw it into the channel, thereby increasing the depth.

To contract the width of the river by moving out one of the banks parallel or nearly parallel to itself cannot be undertaken here. A struggle with the main channel would at once result, and if it succeeded there would be a very marked shortening of the channel and a violent disturbance of the regimen of the river, a thing to be avoided whenever practicable.

It is proposed to accomplish the desired result by running out a series of guiding-banks or training-walls. Just below where the channel strikes the shore and is diverted towards the opposite bank a dike will begin and run out obliquely down stream nearly parallel to the natural channel. Beginning at the foot of Portage Island a dike, H I, is run down stream a distance of 2,900 feet, and then, making an angle, is prolonged 1,800 feet to K. Just below where the channel leaves the Illinois shore a dike, L M, 2,750 feet long, runs nearly parallel to the channel to the small island known as Eagle's Nest. Similar dikes, N O 3,750 feet long, R S 3,400 feet long, and T U 3,450 feet long, are run out from the two banks alternately.

The action of these dikes will not be to check the velocity of the stream and its scouring power, as might seem at first glance. The length of path followed by the water available for navigation, or the channel, will remain the same. The waste water will have its path lengthened and its slope diminished. But in accordance with the general hydraulic law that the larger the stream the greater the velocity, the slope remaining the same, the result of concentrating the water will rather be to increase the velocity. The increase will not be great enough to have any injurious effect.

The longer these dikes are built the more efficient they will be for collecting waste water. Care must be taken that sufficient space be left open between their extremities and the opposite shore to afford free passage for all the water at stages below the height to which they will be built. It is proposed to build them to a height of 10 feet above low-water. The space allowed for the passage of the river at a 10-foot stage is 1,250 feet wide.

A dam, P Q, 875 feet long, built of riprap and timber, closes the chute north of Piasa Island.

It will be necessary to revet the bank from N, 3,750 feet up stream to W, and from K, an equal distance up stream to X, and from T, 3,000 feet up stream to Z.

This outline indicates which part of the present submergible dam, E F, it will be proper to remove. The dam is about 3,125 feet long. The profile constructed upon the map shows, at a point about 800 feet from the island, a breach which extends down to about 1 foot below level of low-water. It is proposed to widen this breach in the direction of the island to a width of 400 feet and to deepen it to a level of 6 feet below low-water. It is thought that when a passage of this size shall be given, the river itself will undermine and remove enough more of the dam to give a free water-way of sufficient dimensions.

What depth of water will be provided by these works at the lowest stage is largely a matter of opinion. Computations based upon the available cross-section left open give but approximations at best. In this case but one side of the channel is confined, the centrifugal force of the water being relied upon to hold it against the dikes. Additional elements of uncertainty are therefore introduced. It is believed that these works will develop the full capacity of the river for navigation, and that a low-water depth of from 8 to 10 feet may be expected. This is more than has heretofore been aimed at. It has been thought by some that a least depth of 6 feet would answer the needs of navigation above Saint Louis. It will be interesting to ascertain by experience whether a greater depth can be procured without adding appreciably to the cost.

It is proposed to build these dikes, except the dam, of a double row of piles, driven through a horizontal mattress or sill, 60 feet wide. made of brush. Each row of piles is to be provided with a sheeting of hurdle work or cheap boards, and the space between the rows is to be filled with sand pumped in from the river-bed. Being built in straight lines the river will not remain in contact with them throughout their lengths but will make deposits on their channel sides until a natural curve is produced. A considerable portion of each will thus be buried in the sand and will be practicably permanent. Such portions as remain exposed to decay must be from time to time repaired and finally provided with a permanent revetment. Constructed in this way the dikes should not cost over $7.50 per running foot. Like all other dikes built in this vicinity they will, until they are consolidated by deposits from the river, be subject to damage from ice gorges, which it is difficult to estimate. A large percentage, 25 per cent., is therefore allowed for contingencies.

The estimate of cost is for—

Dike No. 1, H I K, 4,700 feet long, at $7.50	$35,250
Dike No. 2, L M, 2,750 feet long, at $7.50	20,625
Dike No. 3, N O, 3,750 feet long, at $7,50	28,125
Dike No. 4, R S, 3,400 feet long, at $7.50	25,500
Dike No. 5, T U, 3,450 feet long, at $7.50	25,875
Dam P Q, 875 feet long, at $10	8,750
Revetment, 10,500 feet, at $6	63,000
Removal of 400 feet of old dam, 2,375 cubic yards, at $1	2,375
	209,500
Contingencies, about 25 per cent	52,500
	262,000

It is recommended that these works be constructed in the following order :

1. Removal of a portion of the old dam.
2. Construction of dam P O.
3. Revetment W N.
4. Dike L M.

5. Revetment X R.
6. Dike N O.
7. Revetment Z T.
8. Dike R S.
9. Dike T U.
10. Dike H I K.

And that the funds now available—about $35,000—be employed in beginning them as soon as practicable.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

LETTER OF INSTRUCTIONS TO THE BOARD OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C. October 27, 1880.

SIR: The inclosed project of Capt. O. H. Ernst, Corps of Engineers, for the improvement of the Mississippi River in the vicinity of Piasa Island, with accompanying map, is transmitted for the information and consideration of the Board of Engineers constituted by Special Orders No. 144, par. 1, headquarters Corps of Engineers, current series.

In its consideration of the subject the Board should not only embrace the points presented in the project of Captain Ernst but also those contained in the following interrogatories, viz:

1. Has a sufficient examination been made to determine whether rock exists or not on the new line of proposed channel south of and below Piasa Island, and also above in present channel?

2. Will not a dike, in addition to those proposed by Captain Ernst, be necessary from Portage Island towards, or to, the Missouri shore?

Captain Ernst will be instructed to lay before the Board any information he may have in addition to that contained in his project, and afford its members every facility in his power for a clear understanding of the questions involved.

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By command of Brigadier-General Wright.

Very respectfully, your obedient servant.

JOHN G. PARKE,
Lieut. Colonel of Engineers,
Bvt. Maj. Gen. U. S. A.

Maj. C. B. COMSTOCK,
Corps of Engineers.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., November 24, 1880.

GENERAL; The Board of Engineer Officers constituted by Special Orders No. 144, par. 1, headquarters Corps of Engineers, current series, met at Saint Louis, Mo., at 11 a. m., November 23, 1880.

Having examined the project of Capt. O. H. Ernst, Corps of Engi-

neers, for the improvement of the Mississippi River in the vicinity of Piasa Island, as presented for their consideration by the accompanying letter of instructions of the Chief of Engineers dated October 27, 1880, and having also considered the interrogatories contained in the letter of instructions and the communication submitted to the Board by Capt. O. H. Ernst, they have the honor to submit the following report:

The portion of the Mississippi River for which a project is presented extends from foot of Portage Island to Hop Hollow, a distance of $6\frac{3}{4}$ miles. About the middle of this stretch Piasa Island divides the river into two channels, the main river being to the south and Piasa Chute to the north of the island.

During the years 1875–'76 and '77 a submergible dam closing the southern channel was built for the purpose of throwing more water through Piasa Chute and deepening the channel. Subsequently to the construction of this dam, it was found that a continuous ledge of rock extends from the head of Piasa Island to the Illinois shore, and that the effect of the dam was to increase the current without increasing the depth of water at the head of the chute. This depth is liable to be reduced to 30 inches at extreme low-water.

The plan submitted by the officer in charge for overcoming this obstruction to navigation is to abandon and close Piasa Chute, and adopt the channel south of Piasa Island, making an opening sufficient for purposes of navigation in the old closing dam. The plan further provides for the construction of several dikes or training-walls so arranged as to collect the waste water and direct it into the natural channel of the river. Previous to the construction of these dikes the portion of the shore against which the channel is thrown is to be protected.

The plan proposed for the dikes is to drive a double row of piles through a horizontal mattress 60 feet wide and made of brush. Each row of piles is sheathed with hurdle work or boards, and the space between rows is to be filled with sand pumped in from the river bed. The dams are to be built to a height of 10 feet above low-water, and a clear water-way of 1,250 feet is to be left between the ends of the dams and the main shore.

After a full examination of the maps of the locality and the proposed plans as fully explained by Captain Ernst, we would submit the following as our views:

The abandonment of Piasa Chute and the selection of the southern channel which necessitates the removal of 400 feet, or as much more of the old dam as the interests of navigation may require, and the construction of a closing dam at the head of the chute are approved.

The construction of a dike from the Illinois shore to Eagle Nest Island, 2,750 feet long, is approved, the work to be preceded by the construction of the shore protection rendered necessary by the dike. This dike is shown on the map accompanying the project as on line L M.

It is possible that the effect which it is desired to produce by the dike proposed from the Missouri shore, opposite the head of Piasa Island, may be obtained by raising the portion of the submerged dam; should this effect not be realized, the construction of the proposed dike shown on line N O, may become necessary.

The location proposed for other dikes seems judicious when the present location and condition of the channel are considered; but as the work recommended to be first done is liable to cause changes in the channel we do not feel able to express an opinion at the present time as to the necessity for or proper location of the dike from foot of Portage Island, and of the two dikes below the old submerged dam.

As regards the direction given to the training-walls and the method of construction, we would say that undoubtedly the brush and stone dams, as heretofore constructed on the upper river, would answer well on the stretch of river under consideration, and that the proposed training-wall is considered an experiment, but as all work on the Mississippi River is as yet experimental, and the system of construction proposed is cheap, it is deemed advisable that it be tried. The first dike constructed will fully demonstrate whether or not it will be a success as regards original construction and permanency.

As regards the first interrogatory of the Chief of Engineers relating to rock in the proposed new channel, it may be said that the soundings and general indications, as well as the borings made by Captain Ernst, would indicate that no rock will be found within a depth sufficient for purposes of navigation for all time; but to settle the question it is suggested that Captain Ernst be requested to make a few additional borings in the new channel along Piasa Island near the north end of the old submerged dam and just below Portage Island, near the Illinois shore.

As regards the second interrogatory relating to a dike from Portage Island to the Missouri shore, we would say that a dike from the island to either the Missouri or Illinois shore will be required in connection with the dike from the foot of the island, but that as these works will not affect the constructions recommended, and as the channel may change from one side of the island to the other, it is better to postpone any action upon such a dam until the improvement of that portion of the river is considered.

Very respectfully, your obedient servants,

C. B. COMSTOCK,
Major of Engineers and Bvt. Brig. Gen.
CHAS. R. SUTER,
Major of Engineers.
A. MACKENZIE,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

LETTER OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS, TO THE BOARD OF ENGINEERS.

UNITED STATES ENGINEERS OFFICE,
Saint Louis, Mo., November 23, 1880.

MAJOR: In compliance with the instructions of the Chief of Engineers to lay before the Board any information I may have, in addition to that contained in my project for the improvement of the Mississippi River near Piasa Island, I have the honor to submit the following remarks upon the interrogatories contained in the department letter to the Board of October 27, 1880, an official copy of which has been furnished me:

1. Has a sufficient examination been made to determine whether rock exists or not on the new line of proposed channel south of and below Piasa Island, and also above n present channel?

That is, is the surface of the rock of sufficient elevation to interfere with procuring a proper depth of channel?

Some general indications of what may be expected here are given by

the soundings. Just below the old dam near Piasa Island is a pool 24 feet deep. Above dike T U on the Missouri side is a pool 33½ feet deep, and at the other extremity of this dike is a pool 26 feet deep. The soundings having been taken at a 14-foot stage, the number 14 is to be subtracted from the above to give the depth at dead low-water. Similar pools are found in the present channel above Piasa Island. These pools are separated from each other by the shoal crossings which it is the object of the works to deepen. These shoal places would naturally be expected in their present position if the bed of the river were composed of sand to a great depth. To assume that they are caused by rock would assume a geological formation entirely different from anything to be seen in the vicinity on shore. Under these circumstances but few borings are required to develope the probability into a reasonable certainty that no rock will be found. These few borings have been made as nearly as practicable in the middle of the crossings where the water was most shoal. A pipe was sunk to a depth of from 11 to 20 feet below low-water without finding rock in any case. The position of the borings is shown on the accompanying map.

2. Will not a dike in addition to those proposed by Captain Ernst, be necessary from Portage Island towards or to the Missouri shore?

The works of improvement for any detached section of the river must necessarily bear a close relation to those for the sections above and below, but particularly to those for the one above.

The project under consideration is for the improvement of the Mississippi River from Portage Island to Hop Hollow. It does not include Portage Island, of which the map shows only the lower extremity. The order of construction of the different works recommended in the project places the upper dike, H I K, last. The reason for this was that the plan of this dike depends upon the direction of approach of the channel from above, and it should be constructed in connection with a project for the improvement of the section above. Such a project would, no doubt, include a dam from Portage Island to the Missouri shore, if at the time of its preparation the channel in that vicinity remained as at present. But it is quite possible that when the time arrives for the construction of dike H I K the channel may approach by the south side of Portage Island. In that case the branch H I, instead of being placed as drawn on the map, would be constructed in prolongation of I K to the Missouri shore; and in that case it would not be expedient to build the dam referred to. For it is taken as a governing principle that the main channel is to be interfered with as little as practicable. The works are designed to throw more water into the channel and to make its position permanent, but not to move it. A contrary course leads to increased cost, disturbance of the regimen of the river, and obstruction of navigation during the execution of the works. When a project is being prepared for the section above the present one, if the channel finds itself in the chute south of Portage Island, it would be proper, instead of closing that chute, to arrange works to shut off the water from the Illinois chute; but these cannot be planned until further surveys are made.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Maj. C. B. COMSTOCK,
Corps of Engineers,
President Board of Engineers.

LETTER OF THE CHIEF OF ENGINEERS TO CAPTAIN O. H. ERNST, CORPS OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., November 30, 1880.

SIR: Referring to your project submitted August 26, 1880 (with accompanying map), for the improvement of the Mississippi River in the vicinity of Piasa Island, the inclosed copy of the report of the Board of Engineers, constituted by Special Orders 144, current series, is transmitted for your information and guidance.

The views of the Board are concurred in by the Chief of Engineers.

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Lieut. Colonel of Engineers,
Bvt. Major-General, U. S. A.

Capt. O. H. ERNST,
Corps of Engineers.

R 2.

IMPROVEMENT OF THE HARBOR AND MISSISSIPPI RIVER AT ALTON, ILLINOIS.

The river and harbor act of March 3, 1881, contained the following provision, viz:

* * * And the sums of money heretofore appropriated for the improvement of the Mississippi, between the Illinois and Missouri rivers, and unexpended, are hereby reappropriated, and shall be applied to the improvement of the harbor and Mississippi River, Alton.

The sums of money here described amount to $33,354.70.

An outline of the plan of improvement proposed by my predecessor was given in my last annual report upon the improvement of the Mississippi River, between the Illinois and Ohio rivers.

This plan is, with some modifications in the methods of construction, adopted.

The cost of the first branch of the dike, 4,800 feet long, is estimated to be from $25,000 to $120,000.

It has been impracticable as yet to begin the work, both on account of the high stage of the river and the want of plant, which has still to be accumulated.

Money statement.

Amount appropriated by act approved March 3, 1881	$33, 354 70
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	30 00
July 1, 1881, amount available	33, 324 70
Amount (estimated) required for completion of existing project	86, 675 30
Amount that can be profitably expended in fiscal year ending June 30, 1883.	86, 675 30

R 3.

ICE HARBOR AT SAINT LOUIS, MISSOURI.

At the date of my last annual report, an appropriation of $50,000 had been made by the river and harbor act of June 14, 1880, for constructing an ice harbor at Saint Louis, Mo.

In that report, after giving the proposed location of the harbor, I said:

> There has been no opportunity, as yet, to determine upon a completed project, but enough is known of the locality and the necessities of the case to justify the assertion that the sum asked for, $100,000, is less than will be required to complete the work.

This assumed that the benefit to the commerce of Saint Louis would be sufficient to justify the expenditure. That question was not opened at all. The fact that an appropriation had already been made for the work, seemed to have closed the discussion of that subject.

A plan of the work was prepared as soon as practicable, and forwarded to the department, with my letter of August 16, 1880. This plan was referred to the Board of Engineers for Fortifications and for River and Harbor Improvements.

In the course of my investigations it had become evident that the principal steamboatmen of Saint Louis regarded the construction of the ice harbor with great indifference. Their written evidence to this effect was forwarded to the Board, with my letter of October 15, 1880.

The report of the Board placed this matter in such a light, that it was decided by the department to lay the evidence before Congress before disposing of the appropriation of June 14, 1880.

The papers were forwarded by the Chief of Engineers, October 30, 1880, and by the Secretary of War to the United States Senate, December 11, 1880. They were referred to the Committee on Commerce December 14, 1880, and ordered to be printed, February 5, 1881. They constitute Senate Ex. Doc. No. 43, Forty-sixth Congress, third session.

The new river and harbor bill, containing an additional appropriation of $10,000 for this work, was reported to the House of Representatives, February 3, 1881.

It might seem, at first glance, that a renewal of the appropriation by Congress, after the above-mentioned reports were before it, indicated a desire that the work should go on.

A comparison of these dates, however, would seem to show, that the new evidence was not before the committee engaged in preparing the bill which finally became a law, March 3, 1881.

In consideration of the doubt which may be reasonably entertained as to whether the appropriation of March 3, 1881, was made with a full knowledge of the facts contained in Ex. Doc. No. 43, above referred to, it has been decided by the honorable Secretary of War to postpone the beginning of the work until the matter can again be brought to the attention of Congress.

Money statement.

July 1, 1880, amount available	$50,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$60,000 00
July 1, 1881, amount available		60,000 00
Amount (estimated) required for completion of existing project		122,000 00

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 30, 1880.

SIR: I have the honor to submit herewith a project received from Capt. O. H. Ernst, Corps of Engineers, August 19 last, for the application of the appropriation of $50,000 for an ice harbor at Saint Louis, Mo., by act of June 14, 1880, together with a report from the Board of Engineersfor

Fortifications and for River and Harbor Improvements of the 30th ultimo, to which the subject was referred in compliance with the requirements of the act.

That part of the slough, Cahokia Chute, east of Arsenal Island, which is below the present dam, appears to be conceded as the most suitable portion of the river in the vicinity of Saint Louis to be converted to the purposes of an ice harbor by inclosing it, except at its outlet, by the necessary dikes.

The Board adopts this location and approves the mode of construction proposed by Captain Ernst, with some modifications and recommendations, and also approves the suggestion that the appropriation of June 14, 1880, should be first applied to raising the Cahokia Dam, since the tendency of the present low dam is to cause this slough to fill.

There are differences of opinion, however, as to the absolute need of this harbor and as to its use and availability in protecting the river fleet during winter. This has not escaped the attention of the Board. Such a harbor, it appears, would probably be used almost exclusively by the steamers of the upper river that now take shelter either in the Des Moines Canal or in Alton Slough, and by a small number of boats that fail to reach those harbors; not often by the larger and more costly class of steamers engaged in the lower-river trade. These are compelled, as a matter of profit, to make their trips to the last moment of apparent safety, and if free to move to such a harbor for security would be equally free to move down stream. Still, although the use of the harbor thus becomes limited, absolute immunity to the Saint Louis steamers is not possible, and, in the opinion of the Board, there will always be occasions when an ice harbor would be beneficial.

Since the receipt of this report of the Board, its senior member has transmitted to this office replies from four of the principal steamboatmen of Saint Louis to a circular addressed to them by Captain Ernst asking their views upon the expediency of building the proposed ice harbor. Their replies, also submitted herewith, are unanimous against it, taking into consideration the expense of its construction, the annual cost of keeping it open, and that there are a number of natural ice-harbors in the vicinity of Saint Louis equally accessible. They show, further, that if the government should for any reason fail to keep its entrance open the probability is that the leading steamboat interests would do nothing to make it available.

Whilst approving the views and conclusions of the Board as to the location and manner of construction proposed for this harbor, yet, taking into consideration these facts, coming from a source that merits attention, I beg leave to suggest that the papers now submitted be transmitted to Congress, and that the application of this appropriation be deferred to await such action thereon as this additional information may develop.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY,
Secretary of War.

REPORT OF THE BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS,
AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, September 30, 1880.

GENERAL: The Board of Engineers for Fortifications and for River and Harbor Improvements, to whom was referred, by your letter of the 23d ultimo, the project of Capt. O. H. Ernst, Corps of Engineers, for the application of the appropriation of $50,000, made during the last session of Congress for an ice harbor at Saint Louis, Mo., have the honor to submit the following report:

The only place of refuge in the immediate vicinity of Saint Louis for steamers detained there until the river is closed by ice is Arsenal Island Slough, which, since the construction of the dikes connecting the island with the Illinois shore, is shoaling by deposition of silt. If it can be preserved against further river deposit it will furnish a sufficient harbor of refuge during the ice season for all steamers, barges, &c., that would seek its protection. Formerly this slough constituted the main channel, and steamers were safer along the west concave bank as against ice floes than in the slough itself, save during exceptional winters when no security was to be found in the vicinity. All river improvement, in the neighborhood of Saint Louis for the past fifteen years have narrowed the low-water channel in which the ice floes move and have pressed that channel towards the city shore, so that with the closing of Cahokia Chute there will be less protection at the levee, as the ice field, unable to escape through that passage, will be forced into the west channel. In past years whenever the ice has gorged, choking the whole width of the river, piling up on the banks and on the island from 10 to 20 feet, and followed by floods with a sudden "break up," the destruction to shipping at this port has been very great. Such conditions occurring in the winters of 1856 and 1865, destroyed or seriously damaged the greater part of the steamers at the levee, and again in 1876 some injury resulted to the fleet of boats. With a single channel it is fair to presume that the risks will be increased.

The opinion is entertained by many that since the construction of the Saint Louis Bridge its massive stone piers have exercised a beneficial effect in breaking up and crushing the ice field pressing down from above and also in checking its flow *en masse*, and it would seem from the records of damages for the past ten years that there is good ground for such opinion.

General Simpson, in his annual report dated August 1, 1877 (see Report of Chief of Engineers, 1877, part 1, page 505), sets forth the necessity for converting Arsenal Slough into an ice harbor in forcible terms, and apparently with the result that plans and estimates therefor were called for during the succeeding Congressional session, followed by an appropriation in 1880 for its commencement.

There may be differences of opinion as to the absolute need of the harbor at Saint Louis, and as to its use and availability in protecting the river fleet during the winter.

Whatever may be those differences, it is well known that steamers and barges cannot lie along the Saint Louis river front during the period of ice-bound river without taking the risk of being more or less injured (perhaps destroyed) when the ice breaks up. So well is this understood that since the building of the Des Moines Canal boats engaged in up-river navigation, that can readily reach it, seek its protection during the period of frozen river; others wintering at the nearer point—Alton

Slough. Some probably fail of refuge at either of the above places and are compelled to take their chances elsewhere. But the larger and more costly class engaged in the lower-river traffic cannot be withdrawn from service to go into winter quarters. They must make their trips up to the last moment of apparent safety and endeavor to get away from port before the river is closed. Such steamers will not use an ice harbor at Saint Louis, for if free to move to such harbor they would be equally free to run down stream and make another trip. In point of fact the still water of the harbor of refuge will be frozen probably many days before the river channel is closed, and that circumstance will preclude its use by the above class of steamers, compelled to run as a matter of profit so long as the channel is open.

It would seem, therefore, that an ice harbor at Saint Louis will be used almost exclusively by those steamers and barges that now take winter shelter in the Des Moines Canal and Alton Slough, and by a small number of boats that fail to reach those safe havens. As the lower river fleet is inhibited its use by business interests, some of its steamers will be caught at the Saint Louis levee when the river closes, and, in consequence, more or less injury to them may be anticipated from time to time, dependent upon the unfavorable or favorable conditions attending the breaking up and movement of the ice field. The small losses sustained since 1866 certainly indicate more favorable conditions, and are perhaps in part due to a smaller fleet exposed, to greater care on the part of responsible agents, and to beneficial results to the massive bridge piers above. This almost entire immunity for 14 years, excepting only the year 1876, cannot promise, however, security for the future. An exceptional winter like that of 1865 will lead to exceptional damages, to guard against which the fleet in port, be it large or small, has little or no power. An ice harbor will be of no avail, for the reason that being frozen over it cannot be entered.

The foregoing statements in reference to the service and management of the Mississippi fleet on the approach of severe winter weather, threatening a closed river, is not intended to disparage the benefits to result from the construction of an ice harbor at Saint Louis, but rather to set forth its limited availability and to show that absolute immunity to the Saint Louis steamers is not possible from the nature of the service required of them.

As to the question of the location and method of construction of this harbor there is apparently no difference of opinion. Both General Simpson and his successor, Captain Ernst, have indicated Arsenal Island Slough as the most suitable portion of the river in the vicinity of Saint Louis, to be converted to that use by inclosing it, except at the outlet, by the necessary dikes. The freezing of the river and its opening again occur at comparatively low stages, so that a low dam across the slough and a suitable dike prolongation of Arsenal Island would give the needed inclosure.

The maintenance of this harbor, once created, against filling by silt deposit is, however, the difficult problem connected with its construction, and, to effect that end, it seems necessary to exclude, as far as possible, the river water from entering it, except at its outlet; for, should high-water with every rise of the river flow over the dam and over the east bank on one side, and Arsenal Island on the other, sedimentary deposition would probably shoal the harbor so rapidly as to render it worthless in a short period. As set forth by Captain Ernst in his project now before the Board for its consideration and report thereon, security against such shoaling can only be attained by high dikes. Though

the waters of the river may occasionally rise above the standard high-water mark at Saint Louis (33′.8), the project assumes, we think with sufficient reason, that reference as the suitable height above low gauge for the inclosing harbor dikes. The method of construction proposed, viz, making the dikes solid to a level above the ice range, according to methods already put in practice on the Mississippi River improvements, and finishing with earth mounds protected against the wash of the river currents in high stages by willow growths, will, in the opinion of the local engineer, give security to the inclosing dam and dikes.

In conclusion, the Board approves Captain Ernst's project for an ice harbor at Saint Louis, as to its location and methods of construction, set forth in his report accompanying, but with the following qualifying remarks in regard to the outlet and to the subject of its shoaling by sedimentary deposition; there are no data sufficient to determine even roughly the rate of this filling. The floating sediment varies continuously and irregularly with different gauges of the river and other changes reaching to its most remote sources. Almost daily observations for a year, made available by a multiplicity of computations, would be needed to determine, even approximately, its probable shoaling at the mouth of the proposed harbor, and thence extending somewhat within. It is questionable if sufficient allowance has been made for this deposition, and if the difficulties to result therefrom have not been underestimated. It seems probable that the narrow passage or outlet obliquely crossing the partial eddy below Arsenal Island will fill rapidly. In fact, it may be difficult and costly to retain an open outlet to the harbor, as the flats above and below are built up year by year.

The exact length to which dike M E from the island should extend, as well as its final direction, should be determined from observations made during the progress of the work.

It is the opinion of the Board that the appropriation of $50,000 should be applied to raising the dam C B across the slough to the height of 15 feet, provided it is sufficient for that purpose.

The project of Captain Ernst, with accompanying tracing, are returned herewith.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen.
JOHN NEWTON,
Colonel of Engineers, Bvt. Maj. Gen.
HENRY L. ABBOT,
Lieutenant-Colonel of Engineers, Bvt. Brig. Gen.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

PROJECT OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., August 16, 1880.

GENERAL: The river and harbor act of June 14, 1880, contains the following item, viz:

For ice harbor at Saint Louis, Mo., fifty thousand dollars: *Provided*, That no part of this sum shall be expended until a Board of Engineers shall have been convened and determined upon a plan for the construction of the work.

In compliance with the instructions contained in your letter of July 6, 1880, directing me to "prepare and submit a project for the expendi-

ture of the appropriation referred to, with a view to its reference to the Board of Engineers for Fortifications and River and Harbor Improvements, for consideration," I have the honor to submit the following:

The site of the proposed ice harbor is the chute east of Arsenal Island, or Cahokia Chute. A map of the locality, upon a scale of $\frac{1}{6,000}$, is herewith transmitted. The shore lines within the limits of the proposed harbor, the railroad embankment, and the soundings, are obtained from surveys made during the present month. Lines of levels have also been run upon the lines of the proposed embankments. The rest of the map is compiled from earlier maps. The chute east of Arsenal Island was formerly the main channel of the Mississippi River, but was closed to navigation in 1878 by a low dam, which was built to a height of about 9 feet above low-water, but which has settled about 3 feet. It is that portion of the chute below the dam which it is proposed to convert into an ice harbor.

The object of the harbor is to afford a place where vessels can be laid up during the suspension of navigation in the winter, and be secure from the destructive effects of ice fields when the ice breaks up in the winter or spring. This can be accomplished by raising the present low dam to a proper height. The ice usually forms at the low stages of the river, and is broken up by a sudden rise, the danger to vessels being over before any great elevation of the water is reached. A shelter built to a height of 20 feet above low-water would, I think, afford ample protection.

But in the case of a silt-bearing stream like the Mississippi it is necessary to provide against the destruction of the harbor by deposits of sediment. The great movements of silt take place at the higher stages, and if at such times the waters of the river be allowed to pass freely through the harbor with their normal velocity diminished, as it will be, by the sudden enlargement of water-way below the dam, heavy deposits and a prompt filling up of the harbor may be expected. It is essential for the preservation of the harbor that the flood waters of the river should be kept out of it as far as practicable.

To keep them out altogether would involve the construction of a closed basin with gates of great height. It is to be doubted whether such gates are practicable upon the treacherous soil which characterizes the locality. At all events, their cost and that of the massive embankments required to sustain the pressure of a great head of water would be too great for consideration. A *circulation* of the water can be prevented by inclosing the harbor by dikes built to the height of the ordinary floods. The adjoining land being submergible at flood stages, it will be necessary, besides raising the dam, to construct levees upon Arsenal Island and the Illinois shore. The mouth of the harbor will be left open.

A plan of the works proposed is shown in red upon the map. The dam being raised to a proper height, is prolonged in the shape of a levee, B A, 2,550 feet long, to the embankment of the Cairo and Saint Louis Railroad Company. A levee, C D, starts to the western extremity of the dam, and is carried down in a straight line nearly parallel to the shore, a distance of 4,075 feet, to its intersection with the proposed high-water line of the Mississippi, after rectification. From D the levee is continued upon the later line down to the foot of the island, and is prolonged into deep water at E by a jetty, the distance from D to E being 2,900 feet.

The question whether these dikes should be carried to the extreme height of the greatest floods ever known is a financial one. If the dam-

ages inflicted by floods passing through the harbor at long intervals can be repaired at a cost less than the interest on the investment of capital required to secure this height above that of ordinary floods, it would be economy to stop at the latter level. The flood of 1844 rose to a height of 41′.39 above low-water; that of 1851, 36′.61; and that of 1858, 37′.09. These are the greatest heights recorded at this place. The highest level of the water since 1858 is that of 1876, viz, 32′.06. The Saint Louis city directrix was formerly considered extreme high-water mark. It is 33′.81 above low-water. I think that this may be adopted as the height of ordinary floods. It is quite possible that the river may rise above this level again in the future, but it is extremely improbable that it will do so more often than once in ten years. For every foot that the height of the embankment is increased beyond 33′.8 there will be an addition of about $7,000 to the cost. If it is built higher than that there is no reason why it should stop short of the height attained by the greatest known flood, or 41′.4. This additional height of 7.6 would add $53,200 to the cost of the work, the interest upon which at 4 per cent., compounded for ten years, would amount to $25,548.99. It is probable that any damage which might be inflicted by such exceptional flood could be repaired for a much less sum. The height of 33′.8 above low-water of 1863 is therefore fixed upon as that of the top of the embankments.

The difference of level between the water above the dam and that below may be obtained from the high-water slope of the Mississippi at this point, which is 8″.8 per mile. The level of the water above the dam will be the same as that at the head of Arsenal Island; that below the dam the same as that at the entrance to the harbor. The distance between these points is 2 miles, and the difference of level will therefore be 17″.6. It is the pressure due to this head that the embankment at the upper end will have to resist. The head diminishes as the entrance is approached, but on the other hand this part of the embankment will be more exposed to the shock of running water. A uniform thickness of 10 feet on top, with side slopes of 1 on 2, is therefore adopted for all the embankments, the soil being the light alluvion of the Mississippi Valley.

The available harbor area at dead low-water of 1863 will exceed 50 acres. The average steamboat will cover an area of about 12,000 square feet, and the average barge an area of about 5,000 square feet. An allowance of 50 per cent. additional for the waste space between vessels will be ample. Upon this basis the number of vessels which can be accommodated under the most unfavorable circumstances is estimated at 93 steamboats and 93 barges. A very large increase in the river commerce is thus provided for. As a general rule the water will not fall as low as the level fixed upon as low-water, so that usually there will be more space than that just given. With a comparatively small amount of dredging, the available space can be increased to 150 acres or more, in the future, if it should be desired.

The mouth of the harbor being open, the water will back up through the entrance, and coming to a state of rest will drop a large part of its sediment. The same body of water may be expected to remain in the harbor until the river falls, and having once dropped its load there will be no further damage until the occurrence of another rise. Most of these deposits will take place near the entrance, and this will in time be closed up. It will probably be necessary to dredge a passage through it every year. The length of the proposed harbor is about $1\frac{1}{4}$ miles. The degree of damage which it will suffer from silt deposits will diminish with the distance from the entrance until at the more remote parts there will be

no damage at all. The distance from the entrance to which dredging will be necessary can be ascertained only from experience. In order to ascertain the cost, however, it is desirable to form some estimate of the amount of dredging that will be required. The shape of the harbor is such that, I think, the estimate may be limited to that required to procure a passage 100 feet wide through the shoal at the entrance. The height and width of this are unknown data, but my observation of the river leads me to think that 12 feet above low-water for the former and $\frac{1}{8}$ of a mile, or, say, 650 feet for the latter, are reasonable estimates of what may often occur. Although most of the vessels which use the harbor will be unloaded, and therefore drawing their minimum amount of water, it will sometimes occur that a sudden advent of cold weather will compel a loaded vessel to seek the refuge. Sufficient depth must therefore be provided to admit such vessels; *i. e.*, about 8 feet. The prism of excavation will therefore measure 650 feet in length, 20 feet in depth, 100 feet in width at the bottom, and, with slopes of 1 upon 2, 180 feet in width at the top. It will contain 67,407 cubic yards, which at 15 cents per yard will cost $10,111.05, or, in round numbers, $10,000 per annum. Should the entrance fill only to a depth of 6 feet above low-water and to a width of only 300 feet, as is quite possible, the volume of excavation would be 21,777 cubic yards, and would cost much less, though not in the same proportion, on account of the smaller scale of the operations. On the other hand the fill may sometimes be much greater than that given. It will be necessary to own a dredge and operate it as long as may be required.

Those portions of the proposed works which can be completed without interference from the wash of the river may be built of earth or sand found upon the spot. These include all the levees and so much of the dam and of the jetty at the entrance as lie above an 18-foot stage. For that portion of the dam lying below an 18-foot stage a core large enough to shut off the water must be constructed of riprap, and that portion of the jetty lying below the same level of riprap and brush. All the slopes are to be protected by a plantation of willows. Whether the proposed levees are "buildings" within the meaning of section 355, Revised Statutes of the United States, is a question which, so far as I know, has not heretofore been decided.

The time required for its decision, and, in case the levees are decided to be "buildings," the time required to procure a cession of the land from the legislatures of Illinois and Missouri would cause a delay in the beginning of the work which might be an irreparable injury to it. The operation of the present low dam is to cause the chute to fill up. No time should be lost in raising the dam to a height which will prevent the passage of ordinary high-water over it. The funds now available can be applied to that purpose without raising any question of law. It is important that that should be done before the coming winter, so that the harbor shall be at least partially protected from the freshets of next spring.

The estimate of cost is:

For levee A B, 2,550′ long, having an average height of 7′ 3″ for a length of 1,750′, and an average height of 2′ 3″ for a length of 800′. 12,480 cubic yards of embankment, at 20 cents.	$2,496 00
For core of dam from 6′ above low-water to 18′ above low-water, 1,750′ long, 10′ thick on top, with slope 1 on 1. 17,111 cubic yards riprap, at $1.25.	21,388 75
For widening dam below level of 18′ above low-water to top width of 73′.2. 95,252 cubic yards of earth, at 65 cents.....	61,913 80
For raising dam from 18′ to 33′.8 above low-water, with a top width of 10′ and total lengh 1,875 feet. 45,645 cubic yards earth, at 50 cents	22,822 50

For levee C D, 4,075′ long. 39,784 cubic yards earth, at 20 cents	$7,956 80
For levee D M, 2,000′ long. 35,824 cubic yards earth, at 20 cents	7,164 80
For base of jetty M E, 900′ long, built to a height of 18′ above low water, of riprap and brush, at $40 per foot	36,000 00
For jetty above 18-foot stage. 11,376 cubic yards earth, at 50 cents	5,688 00
	165,430 65
Add for contingencies about 10 per cent	16,569 35
Total	182,000 00

To which must be added the annual expenditure of $10,000 for dredging.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

LETTER OF THE BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, October 19, 1880.

GENERAL: I have the honor to transmit herewith a letter (copy) of Capt. O. H. Ernst, of the 15th instant, inclosing copy of his circular letter to four of the principal steamboat men of Saint Louis upon the subject of the proposed ice harbor at that place, and the replies received thereto. As this correspondence did not reach me in time to send it with the Board's report upon the subject, it is now forwarded in connection therewith.

Very respectfully, your most obedient,

Z. B. TOWER,
Colonel of Engineers and Brevet Major-General,
Senior Member on duty.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

LETTER OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., October 15, 1880.

COLONEL: Upon my return from New York I addressed a circular letter to four of the principal steamboat men of Saint Louis upon the subject of the expediency of building the proposed ice harbor at this place. The object of this letter was to procure in writing and to place upon record the views which they had verbally expressed to me, and which I stated to the Board of Engineers at my recent conference with it. The following papers are herewith transmitted for the information of the Board:

1st. Copy of my circular letter dated October 5, 1880.

2d. Copy of reply from Com. W. F. Davidson, dated October 9, 1880. NOTE.—Com. Davidson controls the Keokuk Northern Line, the largest boating interest of the Upper Mississippi.

3d. Copy of reply from Capt. John P .Keiser, dated October 8, 1880. NOTE.—Captain Keiser manages the largest passenger and local freight business of the Lower Mississippi.

4th. Copy of reply from Capt. Henry C. Haarstick, dated October 14, 1880. NOTE.—Captain Haarstick manages the largest barge and through-freight business of the Lower Mississippi.

5th. Copy of reply from Capt. S. S. Rogers, dated October 12, 1880. NOTE.—Captain Rogers manages the principal steamboat interest of the Missouri River.

These replies are unanimous against the expediency of constructing the ice harbor. They show that if the government should construct the work, and then for any reason should fail to keep the entrance open, the steamboatmen would do nothing to make the harbor available.

So far as the government fleet under my charge is concerned, the additional security offered by the harbor would not be worth any considerable percentage of the estimated cost—$10,000—of keeping the harbor open. My fleet now comprises 2 tow-boats, 1 steam-launch, 16 barges, 6 quarter-boats, 6 pile-drivers, or 31 vessels, besides skiffs, flats, and floating ways. A safe harbor near the city would be a great convenience, but it is not a vital necessity. About $300 per annum would be as much as I should think it expedient to pay for it. That sum would be sufficient to pay for extra heavy lines and several additional watchmen during the few weeks when danger is to be apprehended; and if the vesels are judiciously located when laid up for the winter they will, I think, be reasonably safe.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Col. Z. B. TOWER, *Corps of Engineers,*
President Board of Engineers for Fortifications and River and Harbor Improvements.

CIRCULAR LETTER OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., October 5, 1880.

SIR: You will confer a great favor upon me if you will give me, in writing, your views as to the expediency of constructing the proposed ice harbor at this place, bearing in mind that the work will be a costly one in the beginning, and will be the source of heavy annual expense for its preservation. I should like to be informed as to how much your business would be benefited by it; that is to say, how much you could afford to contribute annually towards its preservation in case it should be abandoned by the government. It will increase the force of your statement if you will give the number of vessels under your control which frequent this port.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

LETTER OF PRESIDENT OF KEOKUK NORTHERN LINE PACKET COMPANY.

KEOKUK NORTHERN LINE PACKET COMPANY,
Saint Louis, October 9, 1880.

SIR: Replying to your favor of the 5th instant, will say it is my opinion that it would be impracticable to build and maintain an ice harbor by dikes and permanent dams, unless at a very heavy cost of building and the expenditure of a large sum in maintaining the same.

If the government should abandon it I do not think steamboat owners would be able to preserve and keep it in order. Our company could not agree to contribute for that purpose.

Yours, respectfully,

WM. F. DAVIDSON,
President.

O. H. ERNST,
Captain of Engineers.

LETTER OF SUPERINTENDENT SAINT LOUIS AND VICKSBURG ANCHOR LINE.

OFFICE OF SAINT LOUIS AND VICKSBURG ANCHOR LINE,
Saint Louis, October 8, 1880.

DEAR SIR: Yours of October 5 to hand, requesting me to express my views in writing as to the expediency of constructing the proposed ice harbor at this place. If I am correctly informed, the place designated is between Arsenal Island and the Illinois shore, the head of which is already or partially dammed.

This place I am satisfied would be of no benefit to the boating interest of Saint Louis, but would make an excellent harbor for flat-boats and boats not used in the winter for a few years; but the expense of keeping it so as to be available for even flats or barges would be so great that the government would soon abandon it.

My reasons for making the above assertion are:

1st. It being so far away from the business part of the city or repair shops, with the river to cross, that it would not be available for repairs, painting, &c., &c., of boats laid up for winter.

2d. The majority of the boats of Saint Louis are seeking business during the winter; the smaller boats going into the southern streams, Yazoo, White, Arkansas, Red River, bayous, lower coast, &c., while the Saint Louis and New Orleans boats proper, and the barge lines, are all seeking business at this season of the year, and do not desire to have their boats above Cairo, when there is any probability of the river freezing up, as the Mississippi River is hardly ever closed below Cairo.

There is an immense amount of business done between Cairo and New Orleans during the winter months.

The cotton crop, oil and seed, and supplies to plantations in return for cotton are all moved during this season of the year.

3d. The nature and character of the river at this point, only 20 miles below the mouth of the Missouri, is that it carries a large amount of sediment or sand, and wherever the current is stopped it will deposit its sediment, and the lower end or entrance to the ice harbor would be at the lower end of Arsenal Island, where there is no current, and where the river is wide, would naturally fill up with this sand or sediment, and the amount of dredging that would have to be done every year would render it impracticable.

We are running, including the Memphis Line, the Vicksburg Line, and New Orleans Line, 20 steamers.

There are a number of excellent natural ice harbors near Saint Louis, and large enough for all our boats. 1st. Behind Quarantine Island; 2d. Platin Rock; 3d. Saline Island; 4th. Chester; 5th. Grand Tower, Powers Island, and others, where there is plenty of water, and the ice cannot get into until broken into small pieces, and the expense of getting our boats to these places would be so small, in comparison with the scheme proposed, that we could not undertake to [do] any part of the work if the government should abandon it.

Yours, very respectfully,

JNO. P. KEISER,
Superintendent Saint Louis and Vicksburg Anchor Line.

O. H. ERNST,
Captain of Engineers, U. S. A.

LETTER OF VICE-PRESIDENT AND GENERAL SUPERINTENDENT MISSISSIPPI VALLEY TRANSPORTATION COMPANY.

OFFICE OF THE MISSISSIPPI VALLEY TRANSPORTATION COMPANY,
Saint Louis, October 14, 1880.

DEAR SIR: In answer to your letter of 5th instant, asking my views as to the expediency of constructing the proposed ice harbor below here, and after taking into consideration the expense of constructing it, and the necessary annual expense of keeping the foot of it open, besides the other expenses, I have come to the conclusion that as far as this company is concerned we would hardly make use of it often enough to warrant any expenditure of money annually, and hence could not promise to contribute anything in case the government should abandon it after completion. Our aim at all times is to keep our boats and barges in open water ready for use when business offers; hence, when cold weather sets in they are left at Cairo, but if a tow (as is sometimes the case) is caught above Cairo in ice, we have found no trouble in finding a natural and safe harbor to get them into; in addition to this, we find that since the completion of the bridge the danger from ice in our harbor has been very much de-

creased, so much so that we do not think the risk of damage great enough to remove any boats we happen to have in our harbor when the river threatens to close.

In conclusion, I beg to state that this company owns and operates 43 barges and 7 tow-boats.

Very respectfully,

HENRY C. HAARSTICK,
Vice-President and General Superintendent.

Capt. O. H. ERNST,
Captain of Engineers, U. S. A.

LETTER OF PRESIDENT KANSAS CITY PACKET COMPANY.

KANSAS CITY PACKET COMPANY,
Saint Louis, October 12, 1880.

SIR: In reply to yours of 5th instant, in regard to the construction of an ice harbor at this place, I will say that in my opinion it is inexpedient.

I am also of the opinion that the business of this company would not be benefited to such an extent as to justify any annual contribution toward the preservation of such a harbor in case it should be constructed by the government and then be abandoned.

This company controls at the present time 2 steamboats and 2 barges which frequent this port.

Very respectfully,

C. S. ROGERS,
President.

Capt. O. H. ERNST,
U. S. Engineer.

R 4.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU, MISSOURI, AND MINTON POINT, ILLINOIS.

A detailed hydrographic survey of this locality was made in the autumn. A project for the improvement was forwarded to the department with my letter of January 12, 1881.

It has not been possible to begin the work this spring, for want of necessary plant. One steam pile-driver has been constructed, and other plant is being accumulated as rapidly as possible. It is expected that the work can be begun within a short time.

Statistics of the commerce of Cape Girardeau for the year ending December 31, 1880, have been collected under my direction, during the past winter, by Mr. Charles Moeller. They are as follows, viz:

	Tons.	Pounds.	Freight charges.
Freight shipped	16,848	771⅓	$62,662 54
Freight received	4,844	1,665	14,593 44
Total shipments and receipts	21,692	2,436⅓	77,255 98

The above includes 2,548 tons and 166 pounds shipped from Cape Girardeau by a firm who do business in East Cape Girardeau, Ill., upon which the charges were $8,522.30.

The expenditures were $4,820.16.

Money statement.

July 1, 1880, amount available	$20,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$30,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		4,820 16
July 1, 1881, amount available		25,179 84
Amount (estimated) required for completion of existing project		60,170 16
Amount that can be profitably expended in fiscal year ending June 30, 1883		60,170 16

R 5.

IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

SHIPLEY'S SHOAL.

(9 miles from the mouth.)

The training wall was extended down stream about 240 feet, but was not completed. The channel depth is less than 2 feet.

RICE'S SHOAL.

(13 miles from the mouth.)

The channel at this shoal having become partially filled up, was excavated to a depth of nearly 2 feet, involving the removal of 720 cubic yards of gravel. Further excavation is necessary.

LOCKETT'S ISLAND SHOAL.

(19 miles from the mouth.)

Similar work had become necessary at this shoal; 352 cubic yards of gravel were removed, deepening the channel to nearly 2 feet. Further excavation is necessary.

BURD'S SHOAL.

(21¾ miles from the mouth.)

The training wall was extended down stream about 500 feet; 372 cubic yards gravel were excavated from the channel, deepening it to 2 feet.

MOORE'S FLATS.

(40 miles from the mouth.)

A straightening of the chute at this place being necessary, that work was begun about two weeks before the close of the fiscal year. Operations had extended only to quarrying a small quantity of rock and beginning the excavation of the new channel.

There had previously been removed from this chute during the year nine snags and forty-three overhanging trees. A depth of 2 feet in the old channel is preserved.

KIRKMAN'S SHOAL.

(47¾ miles from the mouth.)

A break 160 feet long in the training wall was repaired, and a small bar at the foot of the chute was removed by scrapers, deepening the channel to 2 feet.

BERRY'S SHOAL.

(51 miles from the mouth.)

The works designed for the improvement of this shoal were executed in accordance with the plan described in my last annual report. They consist of a cross dam 650 feet long, founded for a part of its length upon an old State work, and of a training wall 2,620 feet long, parallel to the left bank, confining the stream to a width of 80 feet. After their construction a bar was formed at the foot of the chute, the excavation of which was begun, but was not completed. Eighty cubic yards of gravel were excavated by scrapers. Four snags and three overhanging trees were removed. The channel depth is less than 2 feet.

MUSIC'S SHOAL.

(54 miles from the mouth.)

Eighty cubic yards of gravel were excavated by scrapers, deepening the channel to 2 feet; nine snags and thirty-four overhanging trees were removed.

SALINE SHOAL.

(56½ miles from the mouth.)

At this shoal 245 cubic yards of gravel were excavated by scrapers, deepening the channel to 2 feet; thirty-seven overhanging trees and forty-six snags were removed last autumn, and this spring, three snags and nineteen overhanging trees.

TOWN SHOAL.

(59¼ miles from the mouth.)

Ten snags and seven overhanging trees were removed, and 230 cubic yards gravel excavated by scrapers, deepening the channel to 2 feet.

In addition to the foregoing, snags and overhanging trees were removed from the following shoals, viz: Dixon's, Bois Brulé, Hoskin's, and Burdsong's.

The following table gives the amount expended at each locality, including the cost of engineering and contingencies:

Name of work.	Expended prior to July 1, 1880.	Expended during fiscal year ending June 30, 1881.	Total cost to June 30, 1881.
Improvement and surveys (not located)	$139, 254 88		$139, 254 88
Shipley's Shoal		$561 76	561 76
Rice's Shoal		372 88	372 88
Lockett's Island Shoal		157 16	157 16
Burd's Shoal		824 99	824 99
Dixon's Shoal		31 76	31 76
Moore's Flats Shoal		1, 974 52	1, 974 52
Kirkman's Shoal		504 14	504 14
Berry's Shoal		6, 449 95	6, 449 95
Music's Shoal		146 61	146 61
Saline Shoal		919 44	919 44
Burdsong's Shoal		213 27	213 27
Town's Shoal		252 22	252 22
Hoskin's Shoal		325 60	325 60
Bois Brulé Shoal		112 90	112 90
Totals	139, 254 88	12, 847 20	152, 102 08

An attempt was made to introduce the contract system upon such of these works as were capable of detailed specifications in advance.

The lowest bid received was so much larger than what the work had been executed for in previous years, that it would manifestly have been detrimental to the interests of the United States to accept it. All bids were therefore rejected, and the work was carried on as heretofore by hired labor.

The result of the year's work is an extension of the improvement to Tuscumbia, 60 miles from the mouth, and a continuous 2-foot navigation to that place, except at Shipley's, Rice's, Lockett's Island, and Berry's Shoals.

Additional excavation will soon be required at Clark's Island, Bois Brulé, White Oak, and possibly other shoals.

SURVEYS AND GAUGES.

A survey of the river above Tuscumbia as far as Rainey Creek was made in the autumn with a view to preparing plans of improvement. The maps were forwarded to the department with my report of April 21, 1881.

A gauge was established at Tuscumbia and read for the first time on the 25th of August. The zero was placed at what had been low-water mark.

The subsequent removal of Town Shoal, however, lowered the pool above, so that the water has occasionally fallen below the zero. The record is appended, marked B.

In order to give the river-men early notice of a coming rise, a second gauge was, at their request, established this spring at Warsaw, Mo., about 172 miles from the mouth. It was read for the first time on the 7th of June. The record is appended, marked C.

The works upon the Osage River were under the supervision of Mr. W. S. Simpson, assistant engineer, whose report is appended, marked A.

Attention is invited to the statement of the commerce of the river, attached to his report, from which it appears that about 18,400 tons of freight were carried during the year by boat; and 7,000,000 feet of logs and over 1,000,000 railway ties were rafted.

The average charge for freight being $2 per ton, the total freight charges for the year were about $36,800.

A study of the river above Tuscumbia has shown that the system of improvement practiced upon the lower river cannot properly be extended.

It is thought that a lock and dam improvement should not be undertaken on account of its great cost, over $3,000,000, without the express sanction of Congress.

It has, therefore, been concluded to limit operations above Tuscumbia for the present to the removal of such snags and bowlders as may be found in the channel, and the removal of overhanging trees from the banks.

It is proposed to carry this work to Osceola, the head of navigation, about 230 miles from the mouth.

The indefinite character of the work renders it impracticable to make an accurate estimate of its cost, and a new supply of similar obstacles may be expected in the future.

It is thought that the funds now available will be sufficient to do all that will be necessary in the next two years. Accordingly no estimate is submitted for the year ending June 30, 1883.

Money statement.

July 1, 1880, amount available	$30,794 99	
Miscellaneous receipts	32 62	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$50,827 61
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		18,918 73
July 1, 1881, amount available		31,908 88

Abstract of proposals for furnishing the materials and doing the work for the improvement of the Osage River, received in response to advertisement dated August 9, 1880, and opened August 26, 1880, by Capt. O. H. Ernst, Corps of Engineers.

Names of bidders and residence.	Brush.	Stone.	Small stone or gravel.	Sand or gravel excavation.	Labor of men.	Labor of teams, with driver.
	Per cord.	*Per cu. yd.*	*Per cu yd.*	*Per cu. yd.*	*Per hour.*	*Per hour.*
Henry W. Kolkmeyer and Samuel W. Scovem, Jefferson City, Mo.	$1 85	$2 85	$0 65	$0 35	$0 14½	$0 37
J. W. McClurg, Jefferson City, Mo.	2 00	3 00	1 50	1 25	0 15	0 30

A.

REPORT OF MR. W. S. SIMPSON, ASSISTANT ENGINEER.

JEFFERSON CITY, MO., *August* 1, 1881.

CAPTAIN: I have the honor to submit the following report of operations for improving the Osage River, Missouri and Kansas, for the fiscal year ending June 30, 1881.

On the 23d of July, 1880, I was informed by you that the sum of $30,000, appropriated by the river and harbor act of June 14, 1880, was available for improvement of the river, and that so much of it as was required would be employed in extending the training-wall at Shipley's Shoal, extending the training-wall at Burd's Shoal, building the dam and training-wall at Berry's Shoal, in accordance with plans submitted in my letter of March 2, 1880, and in cleaning out Music, Saline, Burdsong, and Town Shoals. The allotments for these localities were as follows: Shipley's Shoal, $5,200; Burd's, $1,200; Berry's, $7,500; Music, Saline, Burdsong, and Town Shoals, $3,800.

The work at Music, Saline, Burdsong, and Town Shoals was to be carried on by hired labor and purchase of material in open market. The work at the other places was to have been carried on by contract.

On the 26th of July I submitted to you the proposal of J. W. McClurg for hire of steamer Emma and barges for work at the shoals of Music, Saline, Burdsong, and Town. On August 3 I was authorized by you to employ the steamer and barges. It was not until the 9th of that month that we were able to get the steamer. On that day we left Osage City, and in proceeding up the river was obliged to stop for half a day at Dixon's Shoal for the purpose of cutting and removing six leaning trees from the bank at the head of this shoal, which had become an obstacle to navigation at this point. I was also obliged to stop at Moore's Flats and remove three large snags which had lodged in that chute. We reached Music Shoal on the 11th. Work at this shoal consisted in cutting and removing from the bank thirty-four trees and in pulling nine snags, also excavating 80 cubic yards of gravel from the channel. The amount expended at this shoal was $146.61. Work was finished at this point on the 15th, and on the same day I moved to and commenced work at Saline Shoal. The work here consisted in cutting from the bank thirty-seven overhanging trees, removing forty-six snags, and in excavating 245 cubic yards of gravel from the same. Work was finished at this point on the 20th. Amount expended, $500.09.

At this time I received instructions from you to transport the surveying party, who were to survey that portion of the river between Tuscumbia and Rainey Creek, from Osage City to Tuscumbia. The steamer went from this point to Osage City and returned with the surveying party to Tuscumbia on the 24th, and I commenced work on the same day at Burdsong and Town Shoals. The work at Burdsong consisted in cutting 14 trees from the bank and removing thirty-eight snags from the channel. Amount

expended on this shoal, $213.27. At Town Shoal of cutting seven trees from the bank and removing ten snags, and scraping 230 cubic yards of gravel from the channel. Amount expended, $252.22. Work was finished at these shoals August the 28th.

The boat and party were then moved to Kirkman's Shoal for the purpose of repairing a break in the training-wall made by ice and rafts, and also to dredge out a small bar at the foot of the chute. The break was 160 feet in length. The bar was about 75 feet in length and extended nearly across the channel. This work was finished September 9. These repairs cost the sum of $504.14.

On August 9 your advertisement for proposals for improving this river at the shoals, where it was intended that the work should be done by contract, appeared, and said proposals were opened by you on the 26th of August, and all bids for the same proving too high, were rejected. And on September 2 I was advised "that all work upon the Osage River under the present appropriation will be carried on by hired labor, and purchase of material in open market," and directing upon the completion of the work at Kirkman's to commence operations at Berry's Shoal. On September 9, the boat and barges were moved to Berry's Shoal. The work to be done at this shoal contemplated the construction of a cross-dam, 650 feet in length, using a portion of the old State dam for the foundation of part of this dam, and a training-wall 2,620 feet in length, contracting the river to a width of 80 feet. On account of a sudden rise in the river we were not able to commence work at this point until the 13th, in the meantime the steamer was ordered to report to Assistant Engineer S. E. McGregory, for the purpose of moving his party from about 10 miles above Tuscumbia to Rainey Creek.

Work on the cross dam at Berry's Shoal was finished on the 20th September, and on the training-wall October 28. This shoal was one that although the bar formed was long and the water spread over quite a distance, the river being at this point 900 feet wide, it was still more susceptible of improvement, and with less expense, on account of having the left bank of the river to work against, than some of the shoals below; there is also an island at this point which divides the river. The plan proposed for this work was to confine the water by a wall parallel to one bank with a channel whose depth were function of the quantity of water, and to decrease the slope by extending the length until the velocity of the water at the stage preceding that of low-water would maintain the channel by its scour. The cross-dam was built of stone, with the exception of that part which closed the chute behind the island, where brush was used for the foundation, the base of the same being about 16 feet, and brought up to 8 feet on top, and built to a height of 2½ feet above low-water. The training-wall was built of brush and rock, the brush being laid at right angles to the current and loaded with rocks, the brush being held in place by stakes. The base of the walls varied from 12 to 14 feet in breadth, according to the depth of water, and was built to a height of 3 feet above low-water. The length of the cross-dam was 650 feet and the training wall 2,620 feet, making a total of 3,270 feet of work. The amount of stone used, which was nearly all got by quarrying, was 5,457 cubic yards, and of brush 895 cords. There was also excavated from the channel 760 cubic yards of gravel, and thirteen snags removed, and fifty-two trees cut from the shore. Total amount expended, $6,200.75.

Work at this point being finished, the boat and barges were moved to Burd's Shoal for the purpose of extending the training-wall built at this place last season. Work was commenced here on November 1, and carried on until the 12th, at which time we had succeeded in extending the wall 500 feet and excavating the channel at the foot of the chute for 150 feet, moving therefrom 372 cubic yards of gravel, and using in the construction of the wall 991 cubic yards of stone. Amount expended, $824.99.

While working at this point I was informed that the shoals at Rice's and at Lockett's Island had become so flattened out as to stop all navigation up the river. These are two small shoals lying between Shipley's and Burd's Shoals. The former between Shipley's and Bolton's, the latter between Bolton's and Burd's Shoals. The first a distance of 13 miles from the mouth of the river, and the latter 19 miles. Upon examination I found that the cuts that had been made through these shoals in 1874 had become so filled up that at Rice's Shoal there was only about 16 inches of water for a distance of 250 feet, and at Lockett's Island only about 18 inches for a distance of 150 feet. I immediately set some teams to work to excavate a channel through these places, and succeeded in excavating from Lockett's Island 352 cubic yards of gravel, at a cost of $157.16, and from Rice's 720 cubic yards at a cost of $372.88.

The weather at this time became very cold, so that it was impossible to make as good channel as I would have liked to have made, but I succeeded in getting a depth of 2 feet through both shoals, and afterwards came through these shoals with the boat and barges. These channels were excavated to a width of 50 feet.

Upon the completion of the work at Burd's Shoal the boat and barges were moved to Shipley's Shoal, and the work of extending the training-wall at this shoal down stream commenced and carried on until November 20. We succeeded in extending the wall about 240 feet, using some 560 cubic yards of stone. Amount expended, $382.16.

At this time the weather became so cold it was impossible to longer continue work, the river on the 22d being frozen over. All laborers were discharged and the steamer laid off. The quarter-boats and barge, with the property belonging to the government, were placed in charge of a watchman for the winter.

The river was closed by ice on November 22, and remained closed until December 9, when the ice broke up, making a suspension of navigation eighteen days. It again closed on the 27th of December, and remained closed until February 8, a total of forty-four days, making a total suspension of navigation on account of ice during the season of sixty-two days. From the time the river broke up in February until the 15th of June, the river has remained at a good boating stage between Tuscumbia and the mouth, the water standing most of the time at an average of 6 feet on the shoals, and for the months of March and April the river was navigable all the way up to Osceola, and several boats made trips up to that point. On April 15 I made an examination of the river from the mouth to Tuscumbia, and reported the result of the same on April 22, as follows: "That there was a bar formed at the foot of the wall at Berry's Shoal, extending from about 60 feet inside of the chute, on which there was only 2½ feet on same. This bar was caused by the scour, where the same has been excavated from the channel at the head of the chute by the current and lodged where the current loses its velocity." I requested authority to be allowed to remove this bar by means of scrapers, and also to remove at several points upon the river some snags which had been lodged in the channel by the spring rises, and to remove some leaning timber from the banks, which were an obstruction to navigation. On the 24th of April I received instructions to resume work upon that part of the river between the mouth and Tuscumbia. Work was commenced same day at Berry's Shoal, excavating a channel through the bar at this point, and carried on until May 5, when the river began to rise to such an extent (the water standing on the Tuscumbia gauge at 5 feet 5 inches). I was obliged to suspend operations. On account of not being able to get a supply of teams I was not able to finish the work at this point. We were only able to remove about 80 cubic yards of gravel. We removed from this place four snags and cut three leaning trees. This work still remains to be finished.

The steamer Emma and barges reported for duty on April 27, and on the 28th work was commenced at Saline Shoal, snagging and cutting overhanging timber. We removed from this shoal three snags and nineteen trees. There was also removed from Hoskin's Shoal nine snags and ten trees cut from the bank; and from Moore's Flats Shoal six snags, and from the bank forty-three trees, and taken from the channel at Bois Brulé three snags.

The river at this time became so high that we were obliged to suspend all operations, and the boat with all the laborers, except a few for the purpose of repairing the property belonging to the appropriation, paid off and discharged.

On May 6 I made application to be allowed to establish a water-gauge at Warsaw, Mo., some 200 miles above the mouth of the Osage. My reason for erecting a gauge at this point I explained in my application as follows:

"Warsaw is now connected with Sedalia by railroad and telegraph, which will allow a notice of a rise in the river at that point to be received at Osage City in time for steamboats to avail themselves of the benefit of the rise. Our Tuscumbia gauge is too far down the river to be used for that purpose, and besides, there being no telegraph line to that place, it is very often the case that boats fail to get the full benefit of a rise before it runs out."

I received instructions from you on May 9 to erect said gauge, but owing to the river remaining so high I was not able to put the same up until the 6th of June.

On the 13th of June, the river having become quite low, preparations were made to again commence operations between Tuscumbia and the mouth. On the 14th and 15th the river was inspected by you from Osage City to Tuscumbia, and then I was instructed to commence operations at Moore's Flats, and straighten the training-wall at that place. In order to do this we will be obliged to remove the large gravel bar which lies next to the bank, and to avoid which the crook in the wall was originally made. This bar is about 200 feet in length and 95 feet in width, and at extreme low-water is about 2 feet above the level of the water, and will require to remove about 2,800 cubic yards of gravel.

On the 17th work was commenced at this point and carried on up to end of the fiscal year.

As a result of this season's work there has been opened up 10 miles more of this river for low-water navigation, and we have reached Tuscumbia with the improvement, and all the work which was contemplated to be done by the project submitted in the beginning of the season finished with the exception of the work at Shipley's Shoal, and but for the cold weather which set in nearly a month sooner this year than last, and the delay caused by waiting for results of bids for the work, which was at first contemplated to be done by contract, we would have finished the work at Shipley's. With the exception of the work at Shipley's, the completion of this system of improving this river between the mouth and Tuscumbia may be said to be finished as far as the same can be done by contracting the channel by means of dams and training-

walls; but there is more work in the way of excavation to be done before we can say that there is navigation for boats drawing 2 feet of water for the entire distance of 60 miles. The completion of these works and the scour caused thereby on the shoals has altered the regime of the river to a certain extent between the places where these works are located.

There are several places between these shoals where the works have been constructed that there is not now a depth of 2 feet at low-water, at which, before the works were constructed, there was that depth of water, and at others where there was not a depth of 2 feet there is more than that at this time. This has been caused in a measure by the building of the dams, which has carried the scour of the shoals where the work has been constructed down and deposited it on the shoal immediately below. The increase in depth is caused by the ponding back of the water to a certain distance by the dams before the same has had time to cut out at the head of the shoal. The fall in this river is about 22 feet in the 60 miles between the mouth and Tuscumbia. Of course nearly all this fall is at the shoals, the fall in the pools at low-water being nearly imperceptible. When a dam has been built it has caused the water to pond back for a certain distance. Wherever there were any of these small shoals that were affected by this ponding back of the water, the depth on the same has been increased, but when we get above the effect caused by the dam holding up the water, the effect has been different and sometimes we notice in low-water a difference on the shoals between the places where the works are located. Take as an example the work at Shipley's the first shoal above Shipley's is Prince's. This lies about 1½ miles above the point where the dam for Shipley's Shoal was constructed. This shoal, before the building of the dam at low-water, never had more than 15 inches of water; since the construction of the dam the water has been ponded back, and there is now never less than 24 inches at extreme low-water.

The next shoal above this is Rice's. Here, before the building of the dam at Shipley's and the dam at Bolton's, which is the next shoal above, there was always at low-water about 18 inches of water. This shoal lies some 4 miles above Shipley's Shoal, and is not influenced in low-water by the dam at this place.

After this dam was put in there was noticed a diminution of depth at Rice's Shoal. There is, I think, but one remedy for this, and that is the dredge, and that may be only temporary.

Dredging by means of scrapers, while it affords temporary relief, is not permanent, and it is almost impossible to get rid of the material scraped out, so that it will not at some stage of the water find its way back into the channel of the river. I think if a suitable dredge-boat was procured and used on this river, and such places as Rice's, Lockett's, Clark's Island, the foot of Bois Brulé, and White Oak Shoals dredged out, and also the bars formed at the foot of the several works now constructed, the material taken from same and placed where it would not again lodge in the channel, that we would then have at low-water a 2-foot channel between Tuscumbia and the mouth of the river. How long the same would remain it is impossible to state, but as the action of the current upon the gravel in this river when not confined is very slow, we have every reason to believe that these channels would remain open for several years to come without further work.

Below you will find a statement of the commerce upon the river for the year commencing July 1, 1880, to July 1, 1881.

Respectfully submitted.

W. S. SIMPSON,
Assistant Engineer.

Capt. O. H. ERNST,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Statement of the commerce upon the Osage River from July 1, 1880, to June 30, 1881.

	Quantity.	Value.
	Tons.	
1,143,040 railroad ties	.....	$457,216 00
4,000,000 feet oak logs, rafted	.....	40,000 00
3,000,000 feet walnut logs, rafted	.....	75,000 00
263,517 feet pine lumber, at $20	373.3	5,270 34
190,000 bricks, at $5	315.2	950 00
1,400 barrels flour, at $6	137.2	8,400 00
80 tons barytes, at $40	80.0	3,200 00
456,791 bushels of wheat, at $1	13,753.7	456,791 00
485 cords of wood, at $2.50	725.0	1,212 50
3,053 tons of miscellaneous freight	3,053.0	.....
Totals	18,473.4	1,048,039 84

The following steamboats have been employed upon the river during the year:

Vessels.	Value.	Trips made.
Steamer Phil. Chappell	$8,000	18
Steamer Aggie	6,000	24
Steamer Tuscumbia	5,500	34
Steamer Coleman	2,500	20
Steamer City of Portsmouth	1,500	10
Steamer Morning Star	3,500	11
Steamer Sport	1,000	45
Steamer Jim Watson	8,000	10
Steamer Emma	3,000	10

Of these the Chappell has made two trips as far up the river as Osceola, the head of navigation, 230 miles from the mouth, and two trips to Warsaw, 172 miles from the mouth. The Tuscumbia and Emma each two as far up as Linn Creek, 110 miles from the mouth, and the Coleman eight trips up to Linn Creek.

The rest of the trips made were only as far as Tuscumbia, 60 miles from the mouth.

The average charge per ton for the freight carried on the lower river—that is, from Tuscumbia to the mouth—is $2 per ton.

B.—*Record of gauge at Tuscumbia, Mo., for the fiscal year ending June* 30, 1881.

[Zero of gauge, low-water of 1854.]

Days.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	.....	.....	0.50	0.05	0.30	0.60	0.65	0.10	14.10	5.30	2.60	3.40
2	.....	.....	0.50	0.05	0.25	0.55	0.65	0.10	14.25	4.90	5.75	3.55
3	.....	.....	0.95	0.05	0.20	0.50	0.60	0.15	14.00	4.55	4.80	3.35
4	.....	.....	7.60	0.05	0.20	0.50	0.55	0.30	13.35	4.25	4.55	2.85
5	.....	.....	8.60	0.00	0.15	0.70	0.55	0.45	12.40	3.95	4.30	2.65
6	.....	.....	8.90	+0.00	0.15	0.60	0.50	1.15	10.90	3.65	5.40	2.55
7	.....	.....	8.70	−0.10	0.15	0.55	0.45	4.25	9.35	3.50	5.55	2.35
8	.....	.....	8.10	−0.12	0.10	0.60	0.45	8.55	7.70	3.35	6.10	2.25
9	.....	.....	7.00	+4.75	0.10	0.75	0.40	13.40	6.45	3.25	9.15	2.10
10	.....	.....	5.65	4.95	0.15	0.80	0.40	14.95	5.80	3.10	9.70	1.80
11	.....	.....	4.10	4.00	0.20	0.70	0.35	14.40	5.70	3.05	8.90	1.60
12	.....	.....	3.05	3.00	0.20	0.60	0.35	14.00	6.25	2.95	8.30	2.50
13	.....	.....	2.40	2.35	0.15	0.55	0.30	13.70	7.15	3.00	7.60	2.45
14	.....	.....	1.85	1.85	0.10	0.55	0.20	14.10	8.40	2.95	6.75	1.65
15	.....	.....	1.50	1.45	0.05	0.80	0.15	14.05	9.90	2.75	6.30	1.20
16	.....	.....	1.20	1.25	1.25	1.10	0.10	13.70	10.90	2.60	5.60	2.30
17	.....	.....	1.05	1.05	1.85	1.00	0.10	12.75	10.65	2.35	4.80	4.30
18	.....	.....	.95	0.85	3.25	0.90	0.10	12.20	9.45	2.30	4.20	5.60
19	.....	.....	.90	0.75	2.65	0.85	0.05	11.40	8.40	2.20	3.65	5.15
20	.....	.....	.85	0.60	2.10	0.75	0.05	9.05	7.45	2.10	3.25	4.40
21	.....	.....	.85	0.55	1.75	0.70	0.10	8.70	6.80	2.05	2.95	3.40
22	.....	.....	.75	0.50	1.30	0.65	0.10	8.80	6.65	1.90	2.75	2.60
23	.....	.....	.65	0.50	1.15	0.70	0.05	9.20	7.30	1.85	2.65	1.90
24	.....	.....	.60	0.50	1.05	0.65	0.05	9.25	9.45	1.80	4.20	1.65
25	.....	0.05	.50	0.90	.95	0.60	0.05	10.30	11.55	1.70	7.40	1.35
26	.....	0.05	.40	0.85	.90	0.60	0.00	11.55	11.25	1.65	7.00	1.30
27	.....	0.05	.30	0.75	.85	0.70	0.00	12.75	10.10	1.60	6.30	1.85
28	.....	0.05	.25	0.65	.80	0.90	0.00	13.60	8.80	1.80	5.70	3.90
29	.....	0.70	.20	0.60	.70	0.80	−0.05	.....	7.60	1.70	4.60	4.20
30	.....	0.65	.10	0.50	.65	0.70	0.00	.....	6.50	1.70	4.10	9.50
31	.....	0.70	.....	.....	.....	0.70	0.10	.....	5.85	.....	3.60	.....

River closed by ice from November 22 to December 9, and December 27 to February 8.

C.—*Record of gauge at Warsaw, Mo., for the fiscal year ending June* 30, 1881.

Days.	January.	February.	March.	April.	May.	June.
1						
2						
3						
4						
5						
6						
7						2.00
8						1.80
9						1.60
10						1.40
11						1.20
12						1.20
13						1.90
14						2.80
15						4.10
16						5.00
17						4.90
18						3.80
19						2.70
20						2.20
21						2.00
22						1.60
23						1.50
24						1.50
25						2.90
26						3.60
27						3.50
28						8.70
29						9.80
30						9.70
31						

R 6.

SURVEY OF THE MISSISSIPPI RIVER AT SAINTE GENEVIEVE, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., December 6, 1880.

GENERAL: I have the honor to transmit herewith a map of the Mississippi River near Sainte Genevieve, Mo., prepared in compliance with the provisions of the river and harbor act of June 14, 1880.

Sainte Genevieve is a town of about 1,560 inhabitants, situated upon the right bank of the Mississippi River, 58 miles below Saint Louis. About $4\frac{1}{2}$ miles above the town is Turkey Island, which formerly divided the river into two chutes, the main channel being sometimes in one chute and sometimes in the other. In order to improve the general navigation and render the channel more permanent, the easterly chute, or the one between the island and the Illinois shore, was closed by a submergible dam (shown upon the map) begun in 1875, the tendency of the river at that time being to desert this chute. (See Report of Chief of Engineers for 1875, page 479, and for 1876, page 639.) This dam has been of great benefit to the general navigation, and the position of the channel may here be regarded as approximately fixed. From Turkey Island the channel now follows the rocky bluff on the Missouri shore down as far as Little Rock, which is about $1\frac{3}{4}$ miles above Sainte Genevieve. Here the bluff makes a sharp turn to the right, while the channel pursues its course in prolongation of the well defined direction which it has received from above, but curving gently to the left. Below Little Rock the river spreads itself out like a fan, and is divided into three arms, each of which has at different periods been the principal arm. At present, the left arm is nearly dry at low-water; the middle arm is the principal one. Sainte Genevieve is situated upon the right arm, its dis-

tance from the principal arm being about six-tenths of a mile. The channel follows the left bank of the middle arm, so that at low-water the distance of Sainte Genevieve from the navigable water in front of it may often be as much as three-fourths of a mile. At high stages the right arm is navigable throughout. At mean stages the upper part of this arm is unnavigable, but boats can run up to the town from below, returning the same way. At low stages even this inconvenient route is closed, and boats are compelled to deliver and receive their freight at a point in the open fields, about $1\frac{3}{4}$ miles below the town, or at Little Rock, which is about the same distance above. The roads leading to these places are shown upon the map. The location of the lower landing upon a caving bank prevents the accumulation of proper means for handling freight, or even the construction of a permanent and good road. Little Rock is better situated for a landing in nearly every respect. But the tow-head which separates the Sainte Genevieve arm from the principal arm of the river extends up stream towards Little Rock in the shape of a submerged bar. Lying just below where the bluff turns to the right and where the channel curves off to the left this bar is liable to receive accretions, and to extend up stream far enough to shut off the Little Rock landing. Much difficulty was found here last year. It can easily be corrected by the construction of a wharf-boat. Any extension of the road and removal of the landing higher up stream is prevented by the bluff, which rises from the water to a height of about 50 feet. It is a nearly vertical bluff of solid rock.

The examination or survey of this locality in the interest of general navigation being provided for in another part of the river and harbor act of June 14, 1880, and in previous acts, by the appropriation of money for the improvement of the Mississippi River between the Illinois and Ohio rivers, it is assumed that this special proviso has an object other than the improvement of the general navigation, and that that is to provide Sainte Genevieve with convenient access to navigable water.

This view is supported by correspondence and conversation with citizens of the place in whose interest the investigation was ordered. It is in that light that the subject of "improvements proper" is here considered.

The only certain means of bringing deep water to Sainte Genevieve is to close the principal arm and the one north and east of Sainte Genevieve Island, thus forcing the main body of the river through the right arm and along the front of the town. A radical change in the position of the channel is thus required. This may be done either progressively by building out the left bank by means of the permeable devices elsewhere employed upon the river, or immediately by building dams across the arms referred to. In the former case an uncertain number of years—probably not less than seven—supposing all necessary funds to be provided, would be required to accomplish the result; in the latter case a stop would be put to navigation during the execution of the works. The relative sizes of the middle and right arms are shown upon the sections. The left arm is at present very small.

The apparent ease with which a small collection of snags or other obstacles can often change the direction of the Mississippi River leads the casual observer to believe that similar results can readily be obtained by artificial obstacles, and that nothing should be easier than to direct the channel according to the will of man. Such a conclusion ignores the fact that the direction of the channel is the resultant of the multitude of forces contributed by every island, every log, every stone, every shifting bar with which the water comes in contact for a hundred miles

above. When a diversion of the channel is easily effected by slight causes, it must be assumed that there was a pre-existing tendency in that direction, and that the apparent cause, such as a snag, was only one of many causes. Indeed, there are many cases where it might properly be considered one of the effects of the pre-existing tendency, and not a cause at all. If the channel could be so easily diverted, it would be singular that the solid banks of sand through which the river plows its way so easily should not be better able to cope with it. A closer examination of the facts in nature shows that any attempt to radically alter the direction of the channel, or, in other words, to contend with the natural tendency of the river, must lead to a struggle to which it will be necessary to bring large means. Nor is it possible to move the channel without either wholly or partially obstructing it, thereby interfering more or less with the general navigation. Such an operation should be undertaken, therefore, only when the interests to be benefited are sufficient to justify large expenditure and some inconvenience to the general public.

In a statement signed by the leading citizens of Sainte Genevieve and forwarded to this office, under date of February 5, 1879, by Hon. Charles C. Rozier, mayor, the annual trade of the town is set down at $600,000, representing between 10,000 and 12,000 tons of merchandise of every description, upon which has been paid between $30,000 and $35,000 freight per annum. It is understood that this refers to the freight transported by river. If the river be brought to the town this freight must still be hauled to the bank. The benefit to Sainte Genevieve must be measured by the difference in cost between hauling it to the landing at the town and hauling it to Little Rock. This difference is estimated at 25 cents per ton. The time during which boats are unable to reach the town on account of low-water may be liberally estimated at two months, and the amount of freight transported during that time at 3,000 tons. The net gain to the town will thus be $750 per annum; $750 is the interest at 4 per cent. upon $18,750—a sum utterly inadequate to create the necessary diversion of the channel.

* * * * * * *

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

R 7.

EXAMINATION OF MERAMEC RIVER, MISSOURI, FROM THE MOUTH TO THE POINT OPPOSITE MERAMEC IRON WORKS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., December 1, 1880.

GENERAL: The river and harbor act of June 14, 1880, provided for the examination or survey of the Meramec River, Missouri, from the mouth to the point opposite Meramec Iron Works, Missouri. This duty, which was assigned to me by your letter of June 17, 1880, has been performed, and I now have the honor to submit the results.

Before sending a party into the field, all available information con-

cerning the river was collected. In the year 1839, a survey of the river was made by the engineers of the State of Missouri, and under date of December 15, 1840, a report upon the subject of its improvement was submitted to the State legislature by Mr. William H. Morell, chief engineer. This report was published in the Journal of the Senate of Missouri for the year 1841. * * * The finished map of the river could not be found; but through the courtesy of Hon. M. K. McGrath, secretary of state, the original field books and some of the rough sheets of original plottings in pencil were procured. From these and from a good map of Saint Louis County a series of working sheets were prepared, covering the entire stretch of river to be examined. They were taken into the field, and rendered it possible to procure and record much more complete and definite information concerning the character of the river bed than would otherwise have been possible in the brief time allowed for the examination.

An effort was made to procure the names of steamboat men or others navigating the river, with a view to ascertain if there were any special obstructions or other special points to which they desire to invite attention. But no such persons could be found. It appears that no navigation of any description now exists upon the river, or has existed during the past year.

The time selected for the examination was in August, when the stream was nearly at its lowest stage. The field work was intrusted to Mr. Max E. Schmidt, assistant engineer.

The accompanying map in 5 sheets, scale 2 inches to 1 mile, has been constructed from the field notes of the old State survey, corrected by sketches made during the examination. The upper 28½ miles of the stream is so narrow that it has been necessary to distort the map by doubling the width, in order to show the obstructions to navigation. For convenience in reference, stations for every mile are marked and numbered consecutively, beginning at the mouth. The map embraces all that may properly be termed the Meramec River, the Meramec Iron Works being at the head of the river proper.

The report of Mr. Schmidt, assistant engineer, to which attention is invited for a detailed description of the stream, is appended.*

A careful consideration of all the data available leads to the following conclusions:

1st. The Meramec is not now a navigable river in fact.

2d. It is not capable of such improvement as will make its navigation "safe and convenient for the naval and commercial vessels of the United States," or will "adapt it to the commerce of the country through which it flows."

3d. The lower 21 miles, being under the influence of backwater from the Mississippi, may possibly prove an exception to this rule for at least a portion of the year; but, owing to the small amount of commerce that such restricted improvement would benefit, there being none upon the river at this time, the exception is unimportant. A detailed survey, and a daily gauge record covering the period of a year, would be necessary to determine what depth and width of water could be secured. The motive power upon this portion of the river must be steam, and that would necessitate the removal of, or construction of draws in, four bridges, among which are an iron truss bridge and a wire suspension bridge.

4th. The agricultural and mining industries of the country through

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*Omitted. Printed in Senate Ex. Doc. No. 44, Forty-sixth Congress, third session

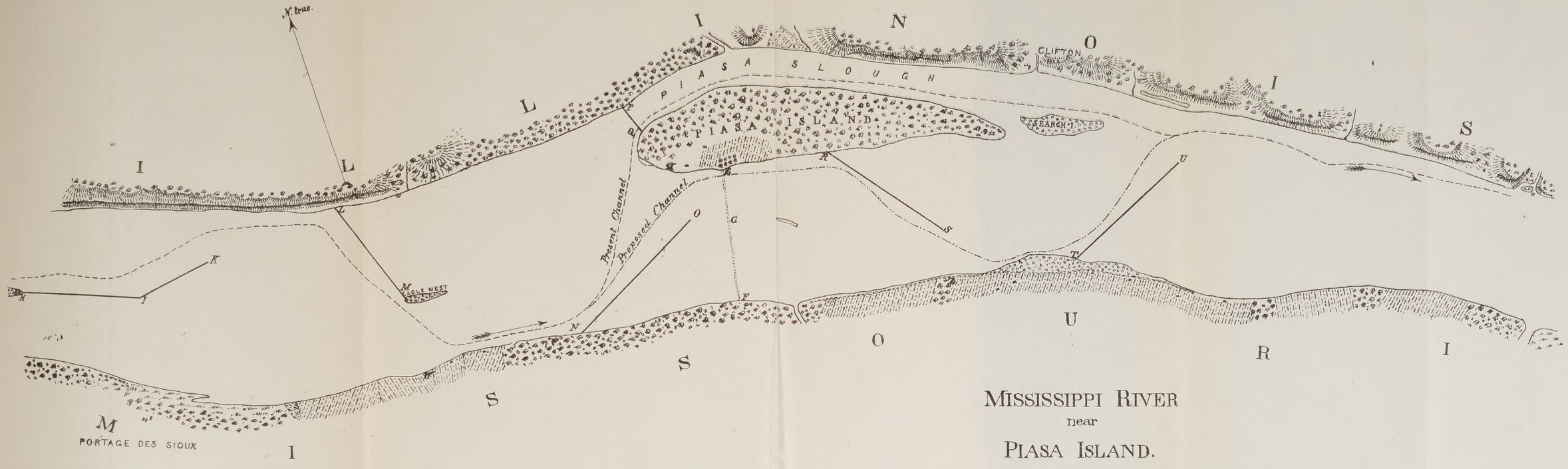
which the river flows are large and increasing. They are provided with rail transportation, but would be greatly benefited by cheap transportation by water. A canal, wholly or partially independent of the river, has been suggested; but this is an independent scheme, and cannot properly be called an improvement of the river.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Plate No.1.

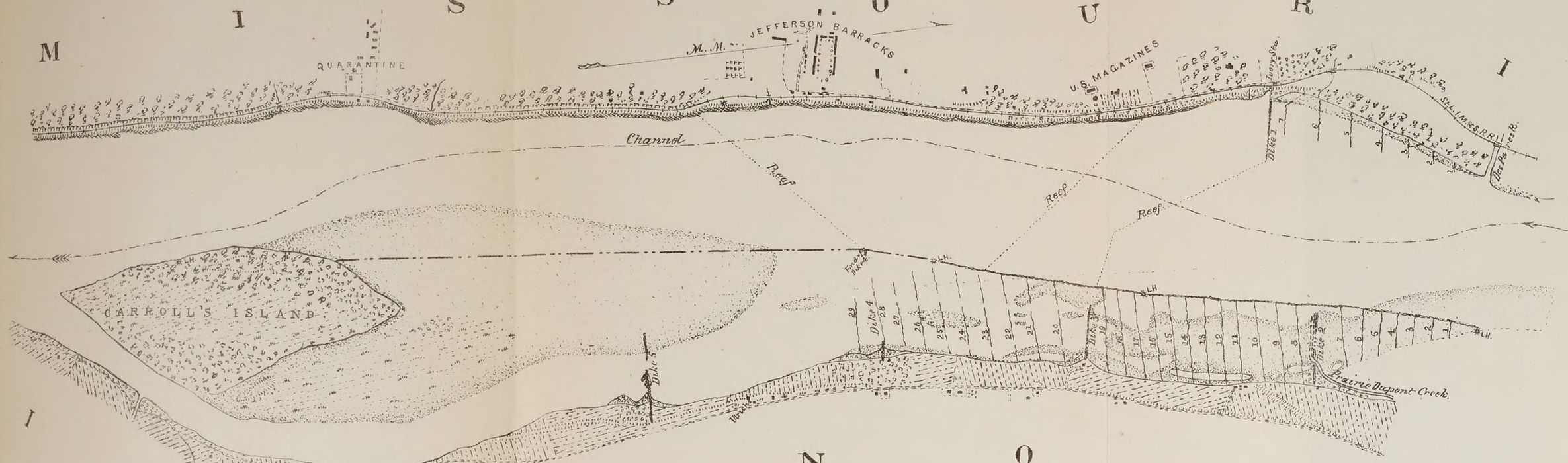


MISSISSIPPI RIVER
near
PIASA ISLAND.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

Plate No. 2.



MISSISSIPPI RIVER.
HORSETAIL BAR.

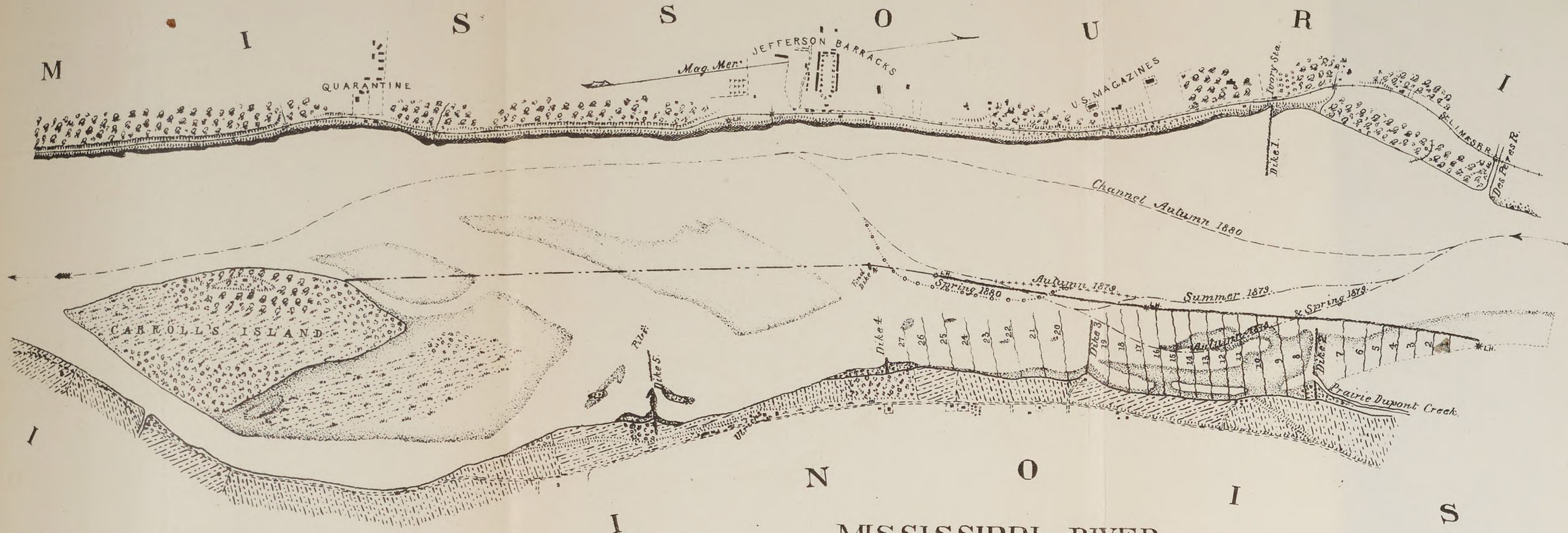
Map showing location of works June 30th 1881.

Bars are shown as they appear at a 15' stage.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10000 Feet.

Plate No. 3.



MISSISSIPPI RIVER.
HORSETAIL BAR.

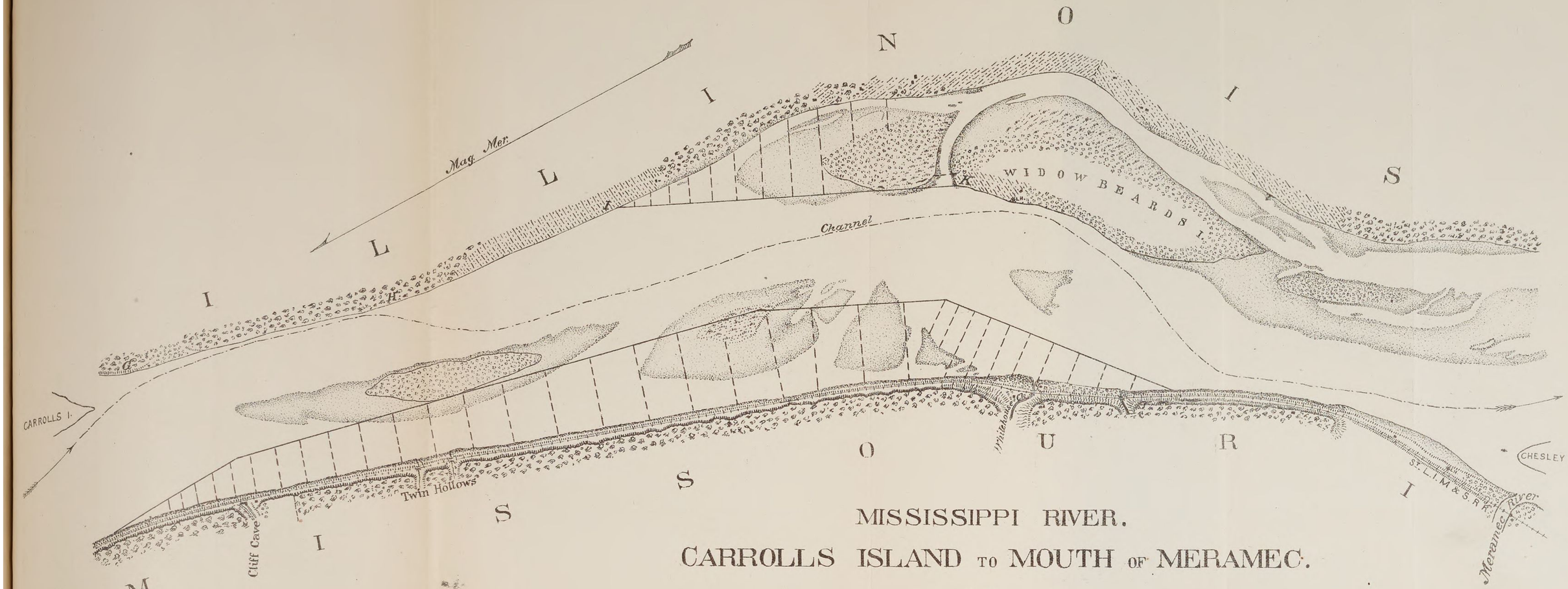
Map showing location of works June 30th 1880.

Bars are shown as they appear at a 15' stage.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10000 Feet.

Plate No. 4.



MISSISSIPPI RIVER.

CARROLLS ISLAND TO MOUTH OF MERAMEC.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

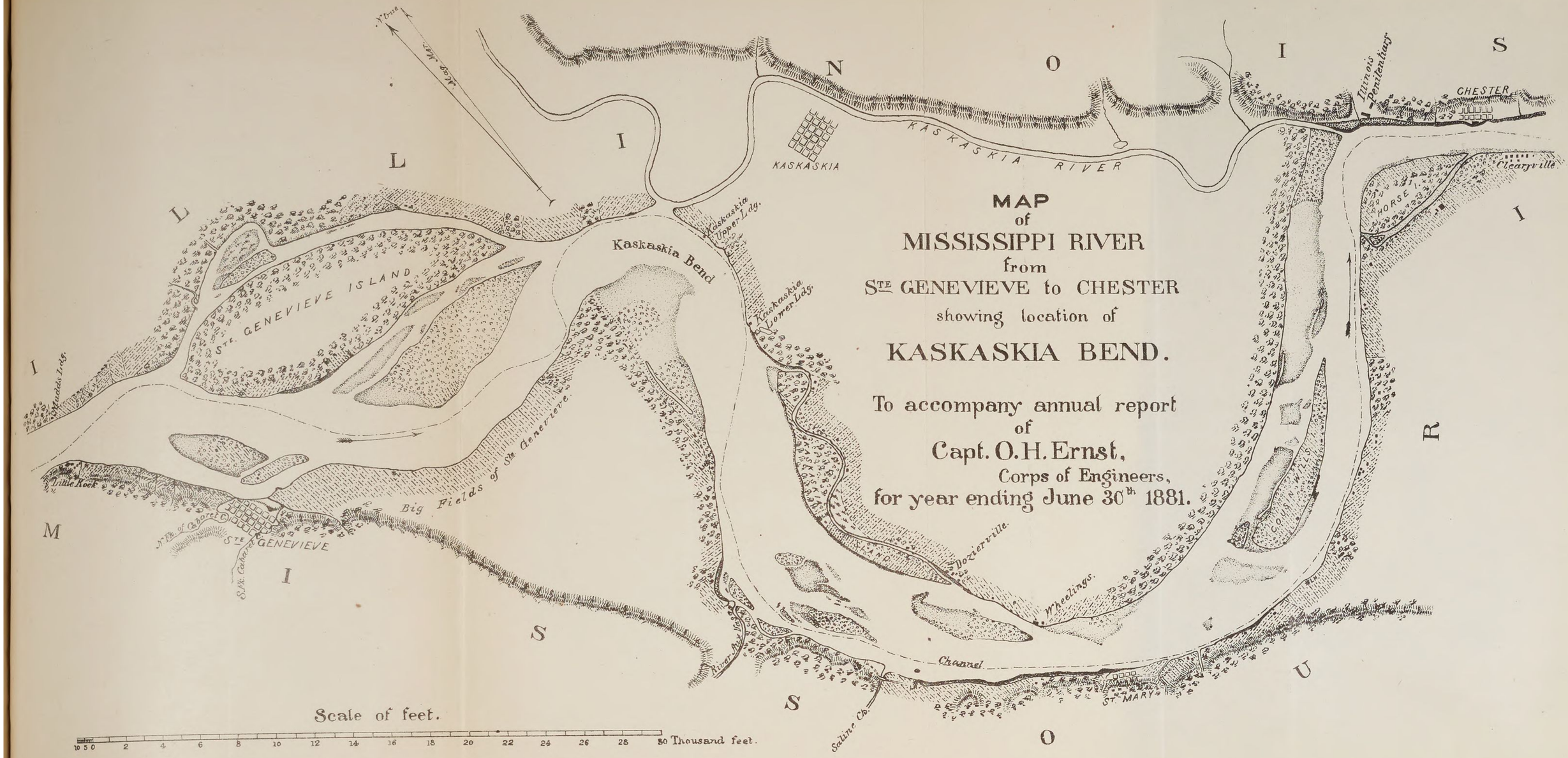
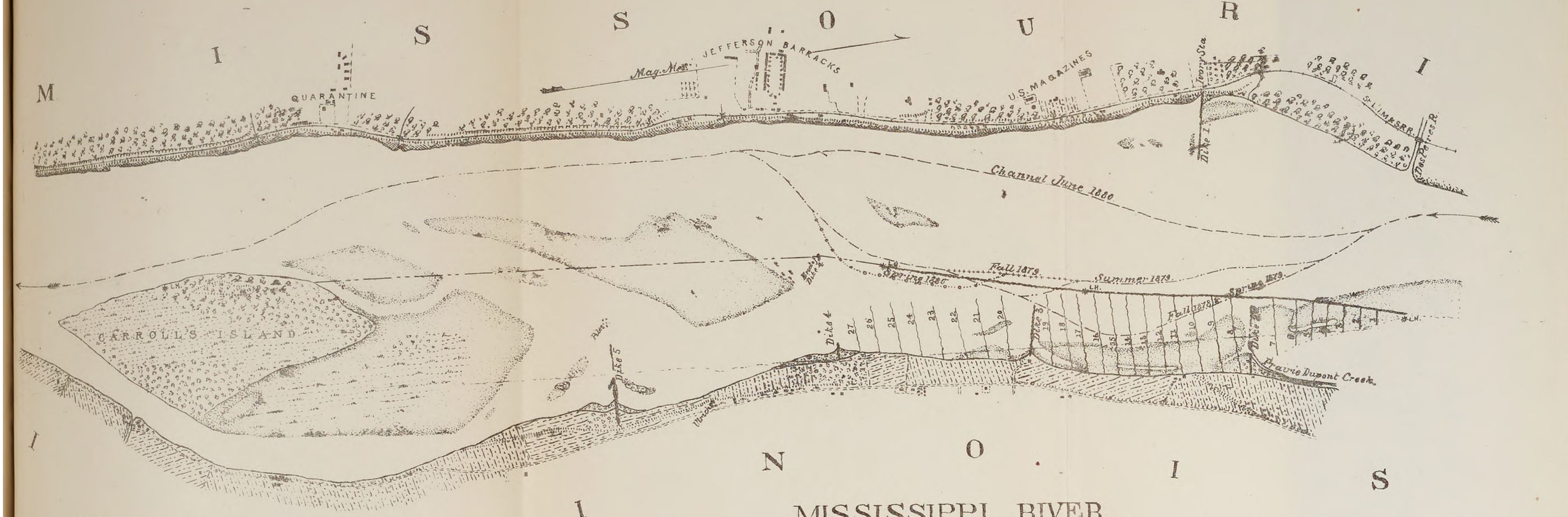

MAP
of
MISSISSIPPI RIVER
from
Ste GENEVIEVE to CHESTER
showing location of
KASKASKIA BEND.
To accompany annual report
of
Capt. O. H. Ernst,
Corps of Engineers,
for year ending June 30th 1881.
ILLINOIS
MISSOURI
KASKASKIA
KASKASKIA RIVER
CHESTER
Illinois Penitentiary
Kaskaskia Bend
Kaskaskia Upper Ldg.
Kaskaskia Lower Ldg.
Ste. GENEVIEVE ISLAND
Big Fields of Ste Genevieve
Ste GENEVIEVE
Little Rock
Dozierville
Wheelings
Channel
Saline Ch.
Clearrville
HORSE I.
COLWELLS
ST. MARY
Scale of feet.
10 5 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 Thousand feet.

Plate No. 6.



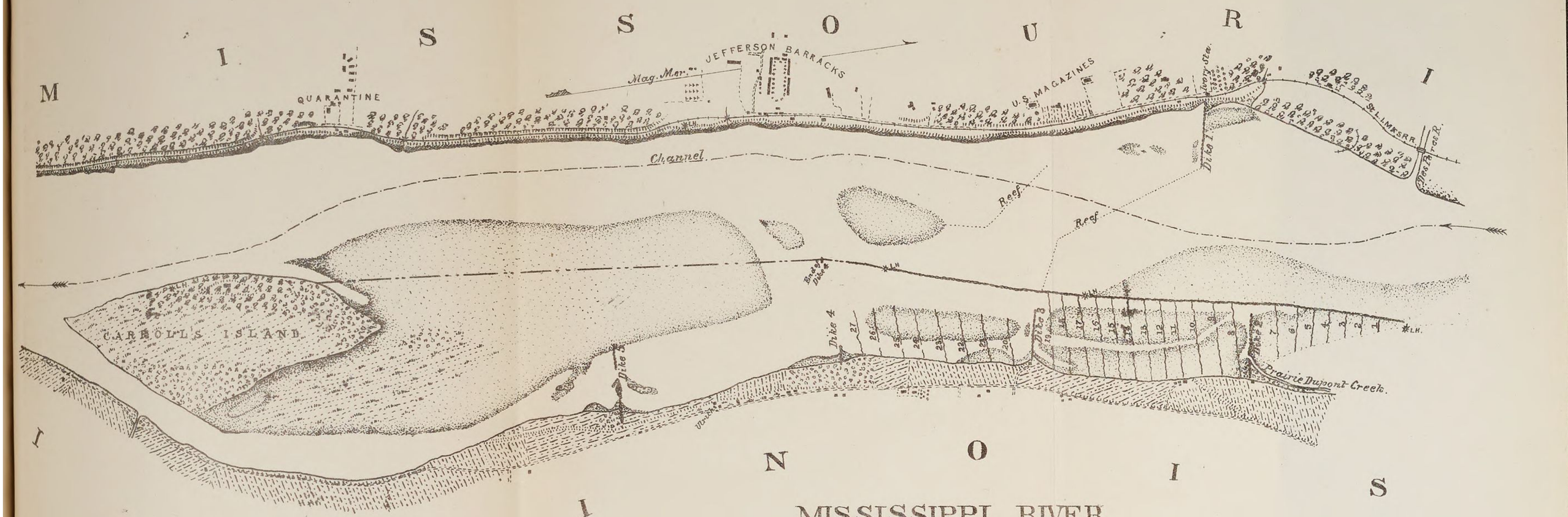
MISSISSIPPI RIVER.
HORSETAIL BAR.

Sketch showing condition of works June 30th 1880.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

Plate No. 7.



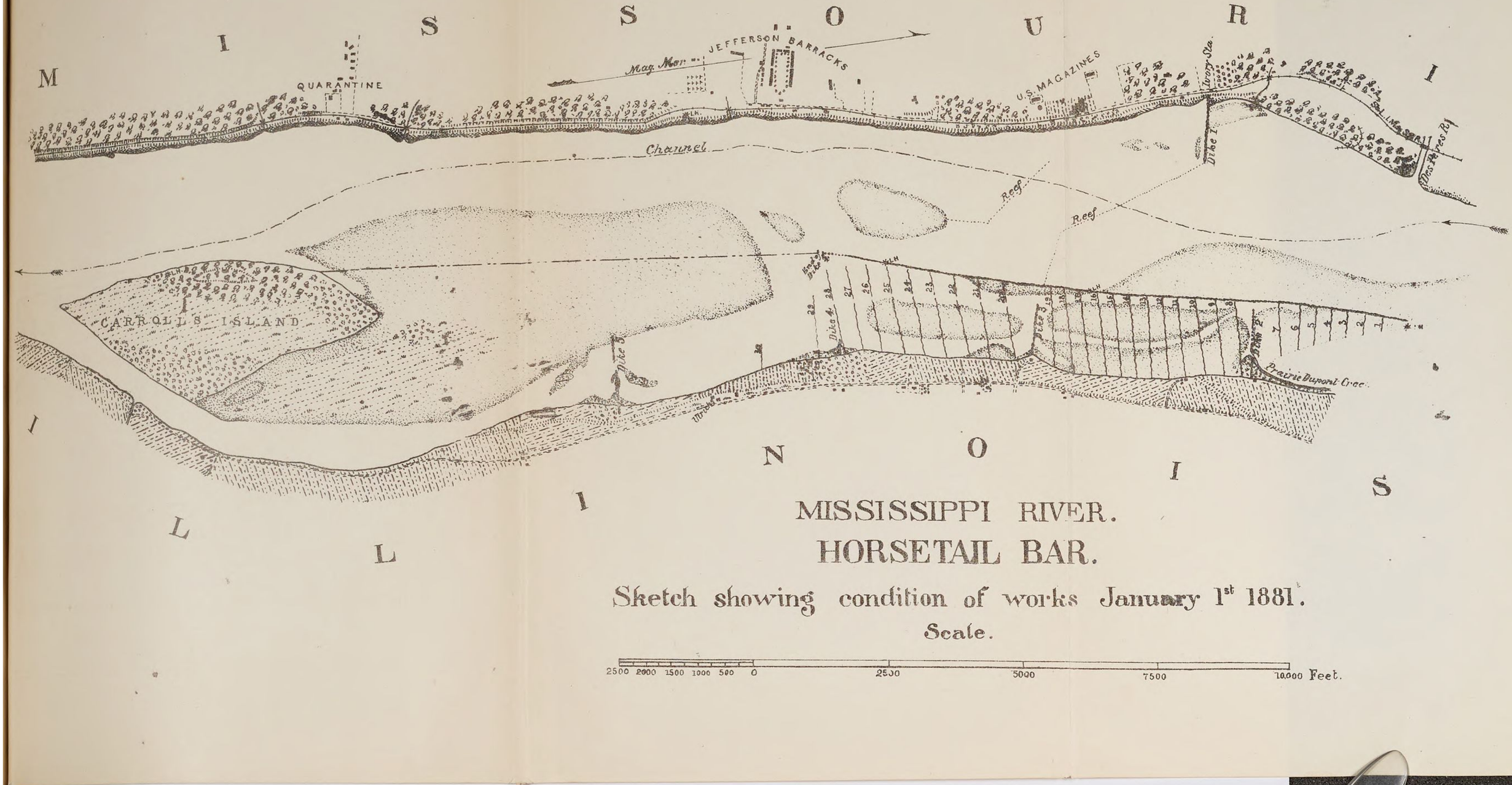
MISSISSIPPI RIVER.
HORSETAIL BAR.

Sketch showing condition of works Aug. 1st 1880.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

Plate No. 8.



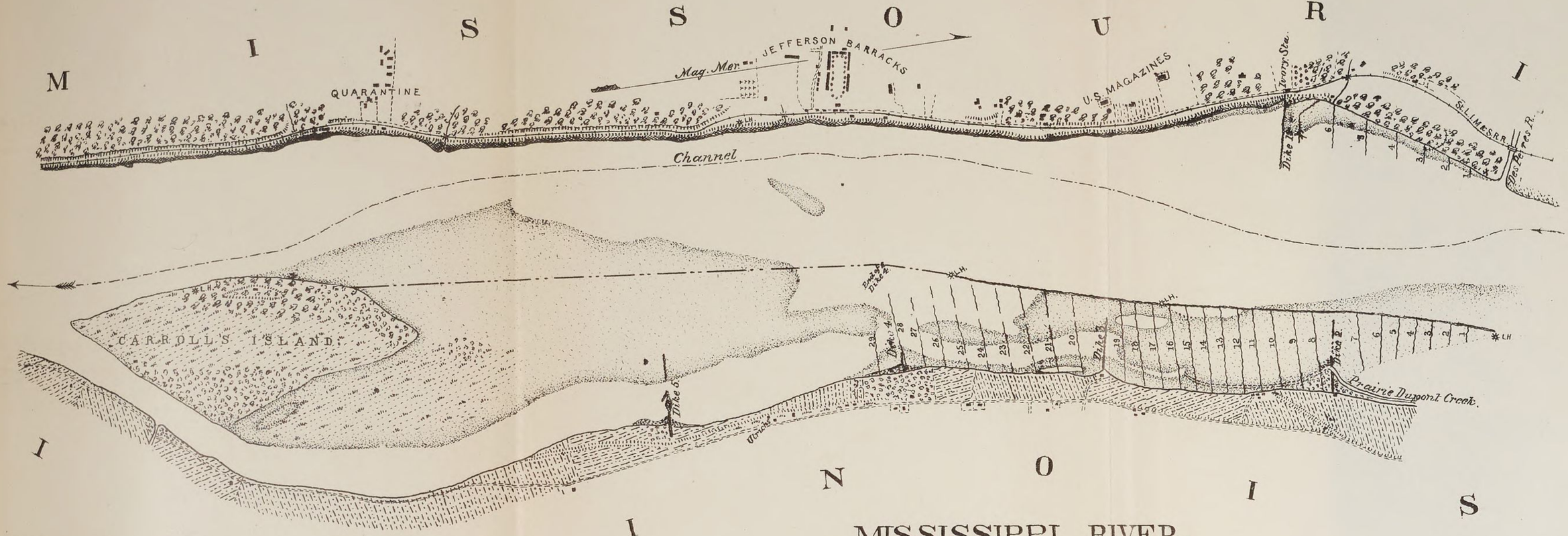
MISSISSIPPI RIVER.
HORSETAIL BAR.

Sketch showing condition of works January 1st 1881.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

Plate No. 9.



MISSISSIPPI RIVER.

HORSETAIL BAR.

Sketch showing condition of works June 30th 1881.

Scale.

2500 2000 1500 1000 500 0 2500 5000 7500 10,000 Feet.

MISSISSIPPI
INDUSTRIAL

Plan.

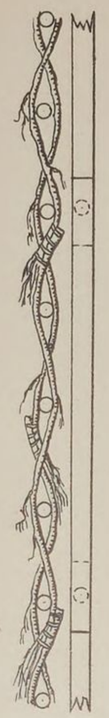


Fig. 1.

Section.

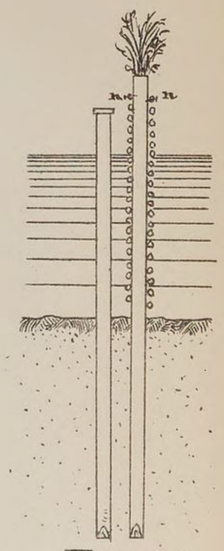


Fig. 2.

Elevation.

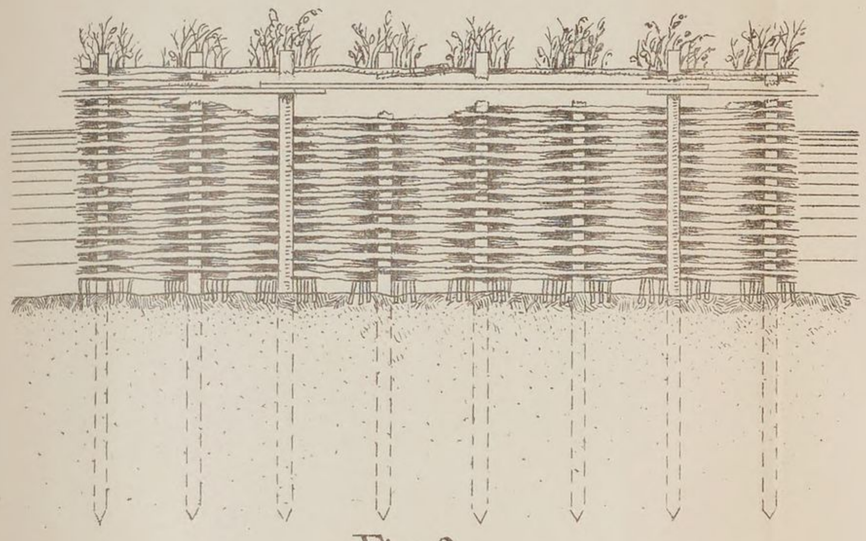


Fig. 3.

Section.

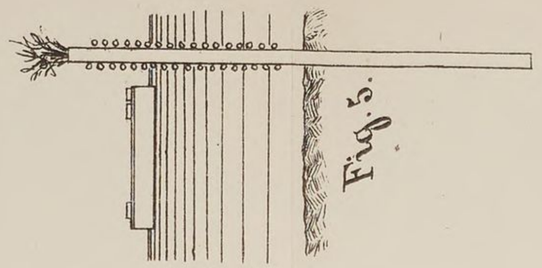


Fig. 5.

Plan.
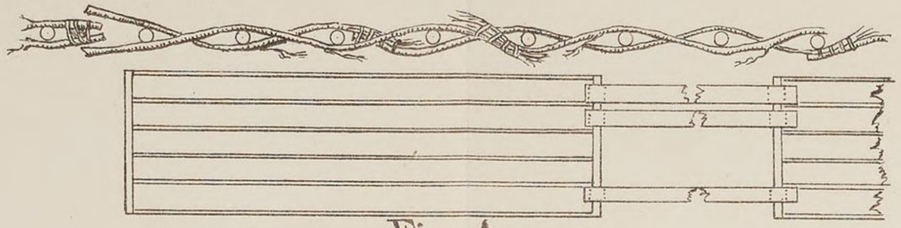


Fig. 4.

Elevation.

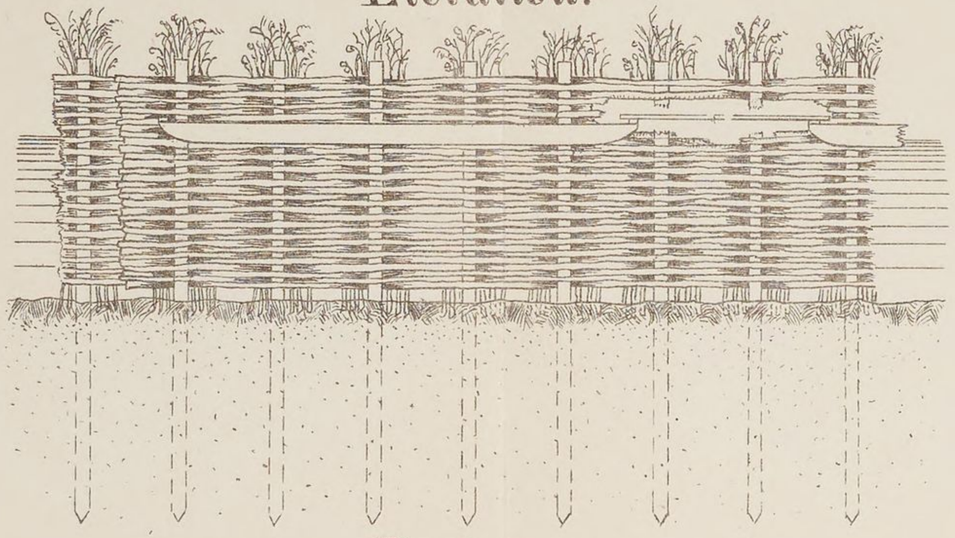


Fig. 6.

Plan.

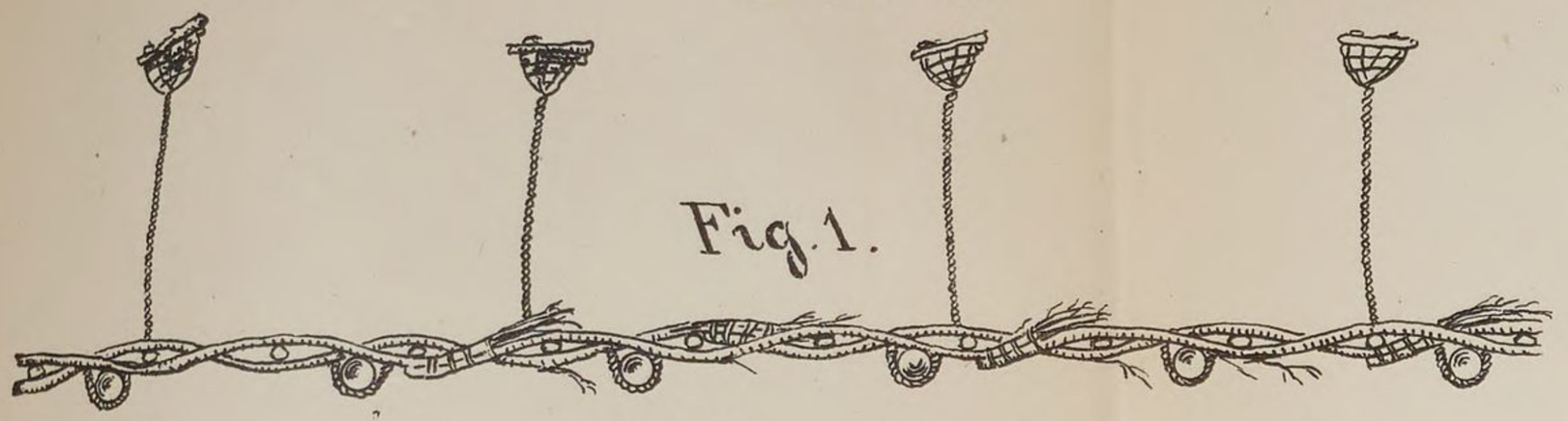


Fig. 1.

Elevation.

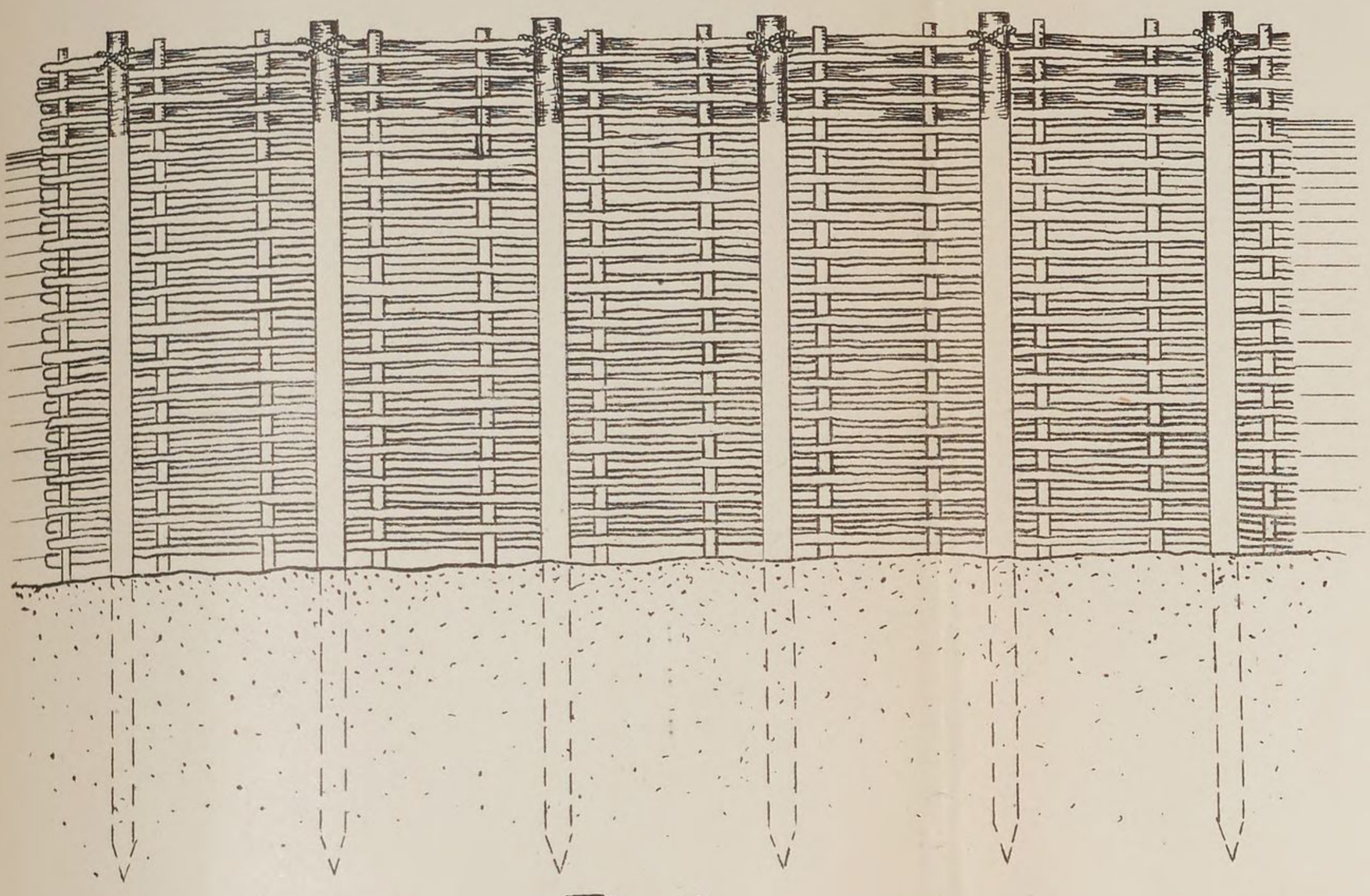


Fig. 3.

Section.

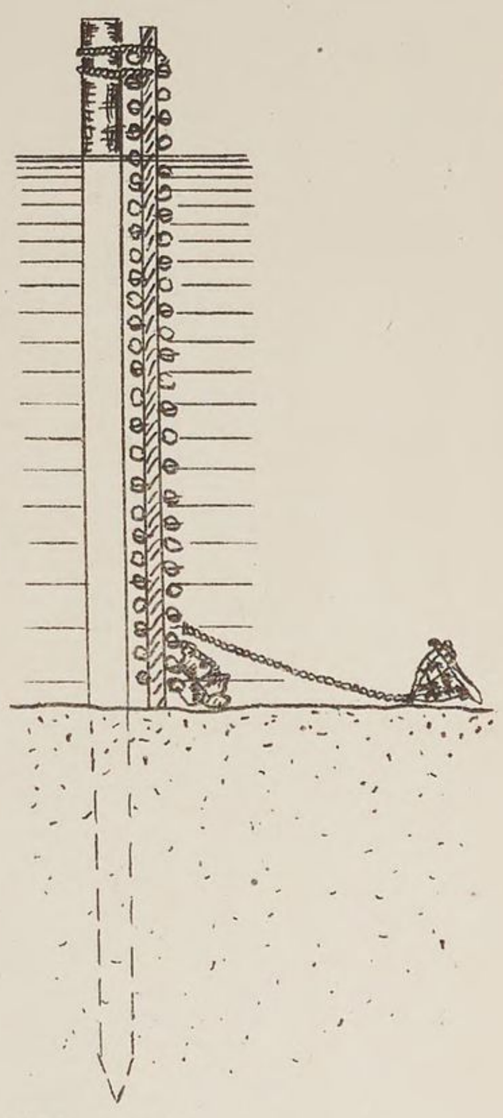


Fig. 2.

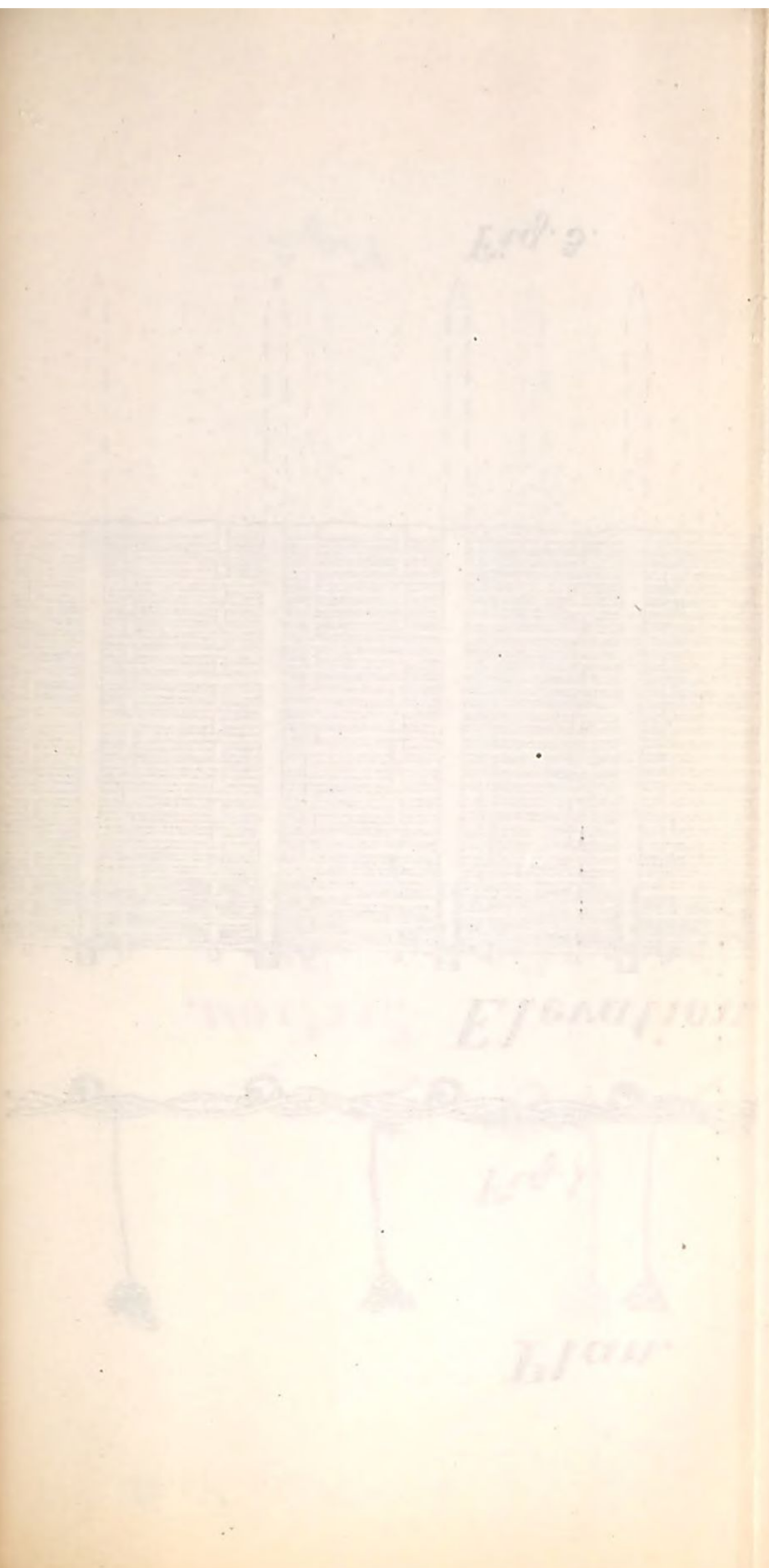


Plate No. 12.

Horizontal Section.

Fig. 1

Elevation

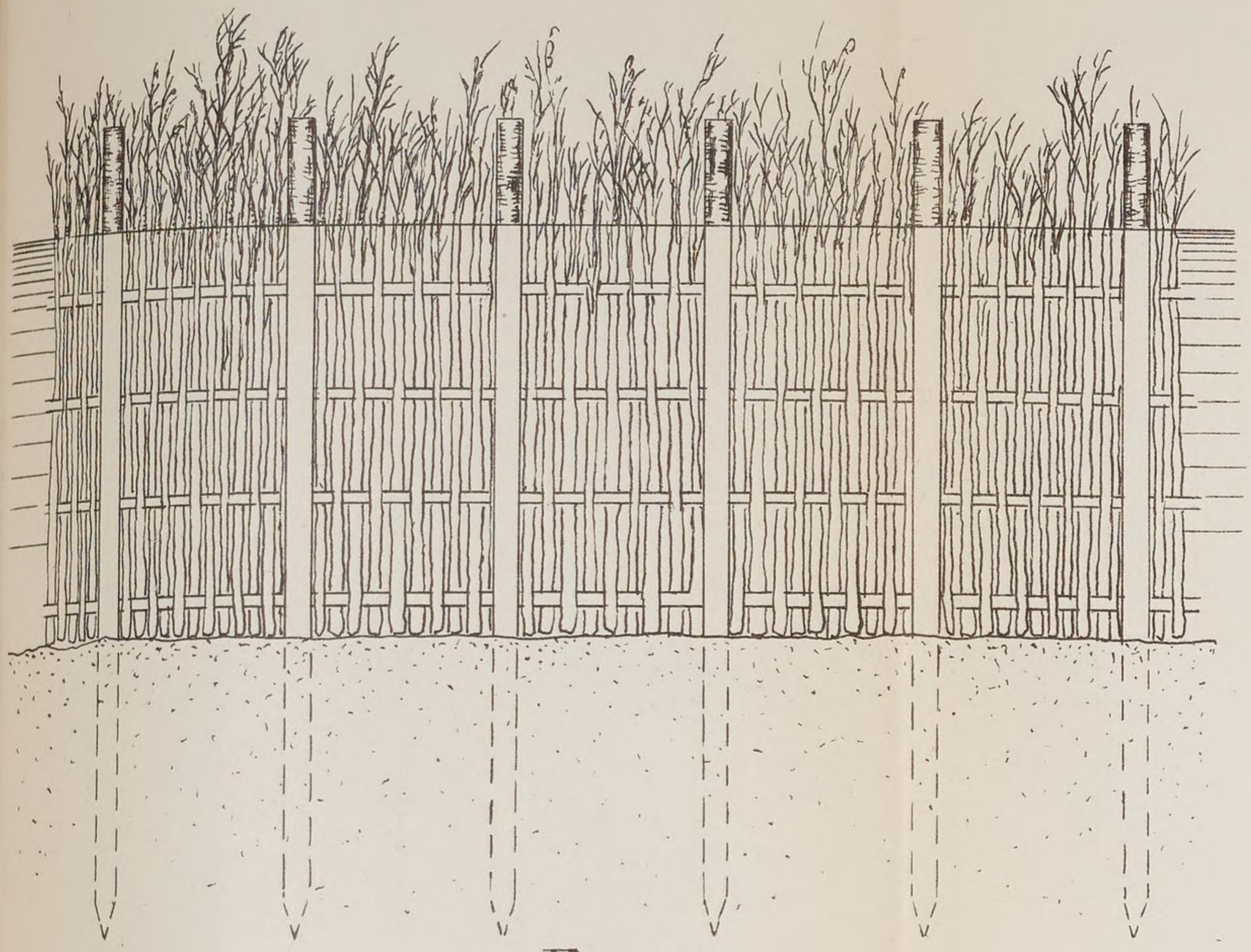


Fig. 3.

Vertical Section.

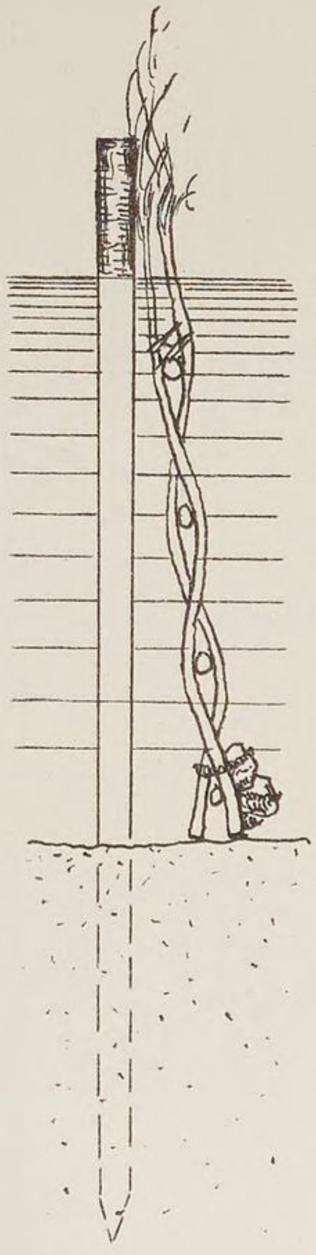


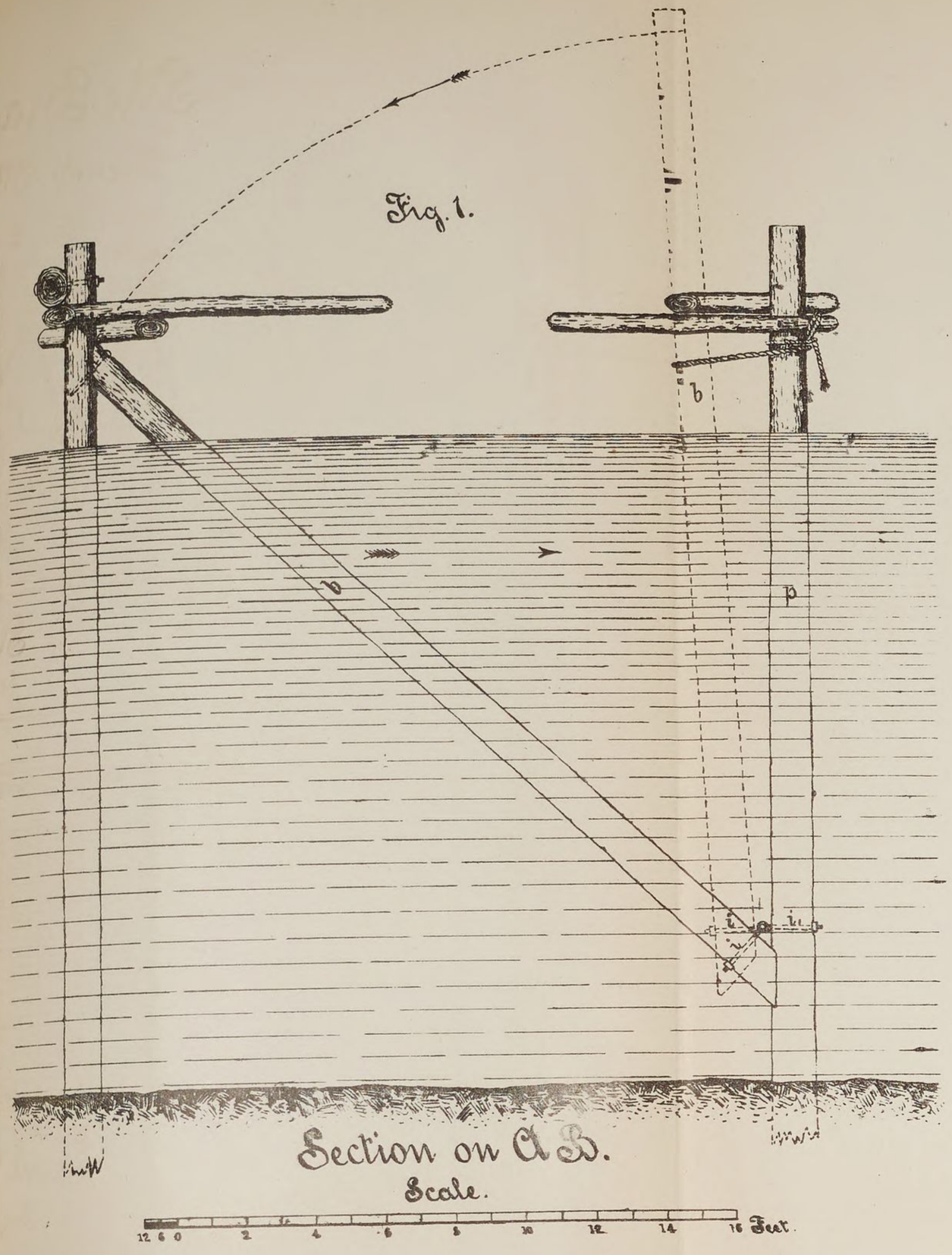
Fig. 2.

Plate No. 13.

Pile Bracing.

Second Method.

Fig. 1.

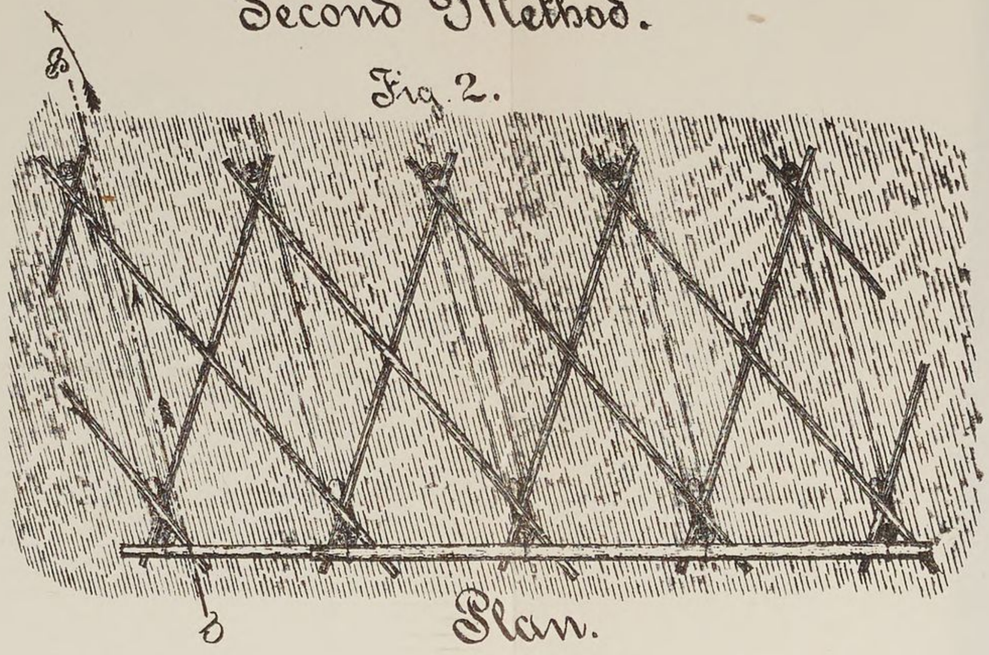


Section on A B.

Scale.

12 6 0 2 4 6 8 10 12 14 16 Feet.

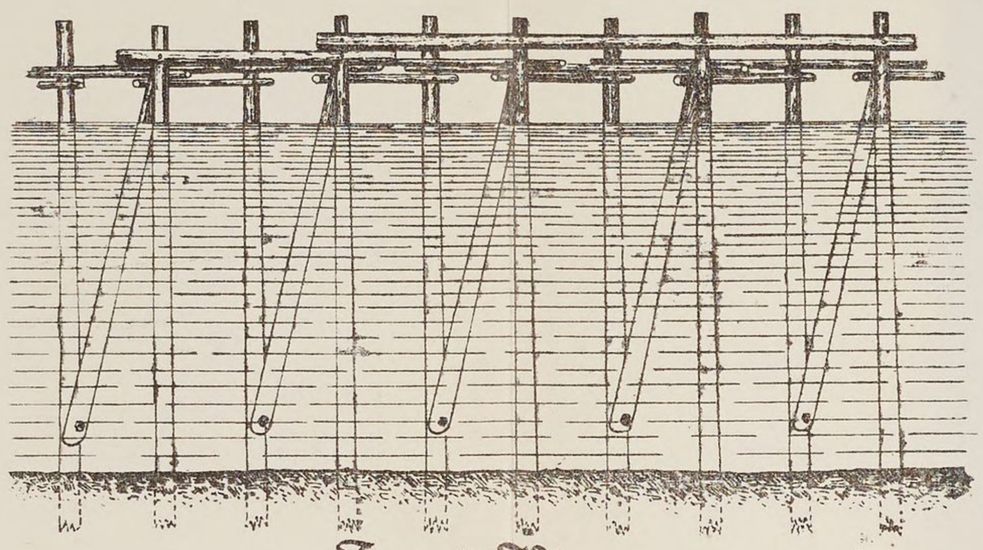
Fig. 2.



Plan.

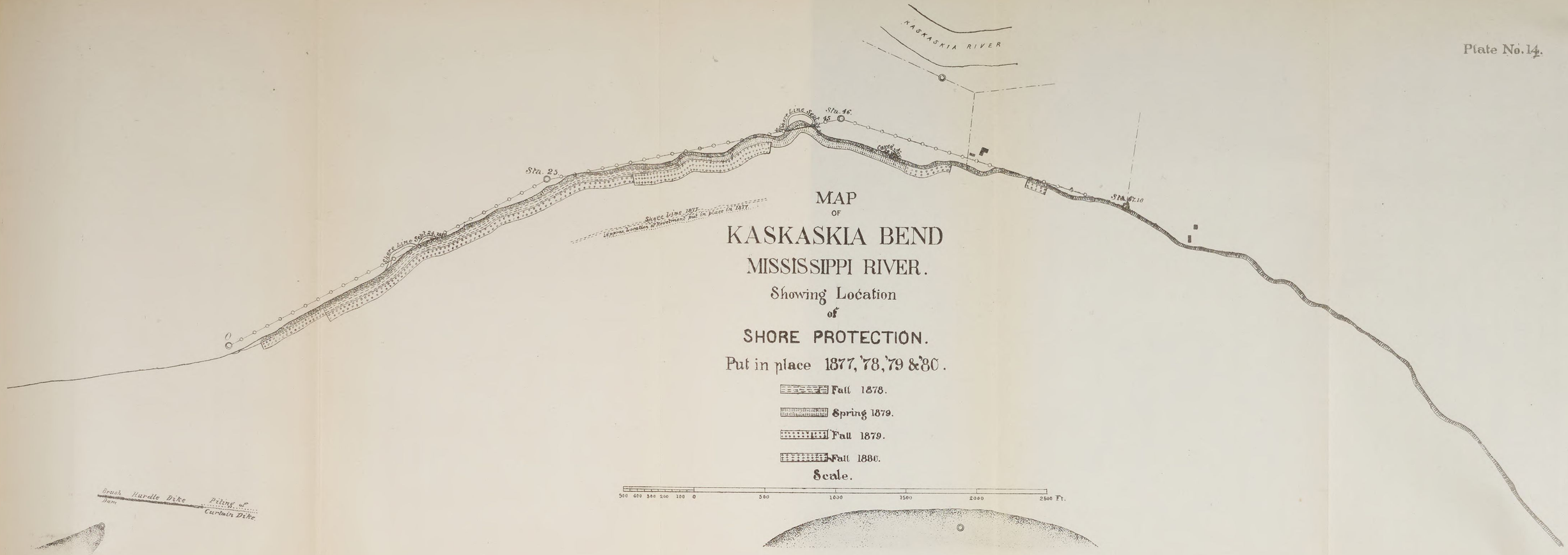
Scale.

10 5 0 10 20 30 40 Feet.



Front View.

Fig. 3.



MAP
OF
KASKASKIA BEND
MISSISSIPPI RIVER.
Showing Location
of
SHORE PROTECTION.
Put in place 1877, '78, '79 & '80.

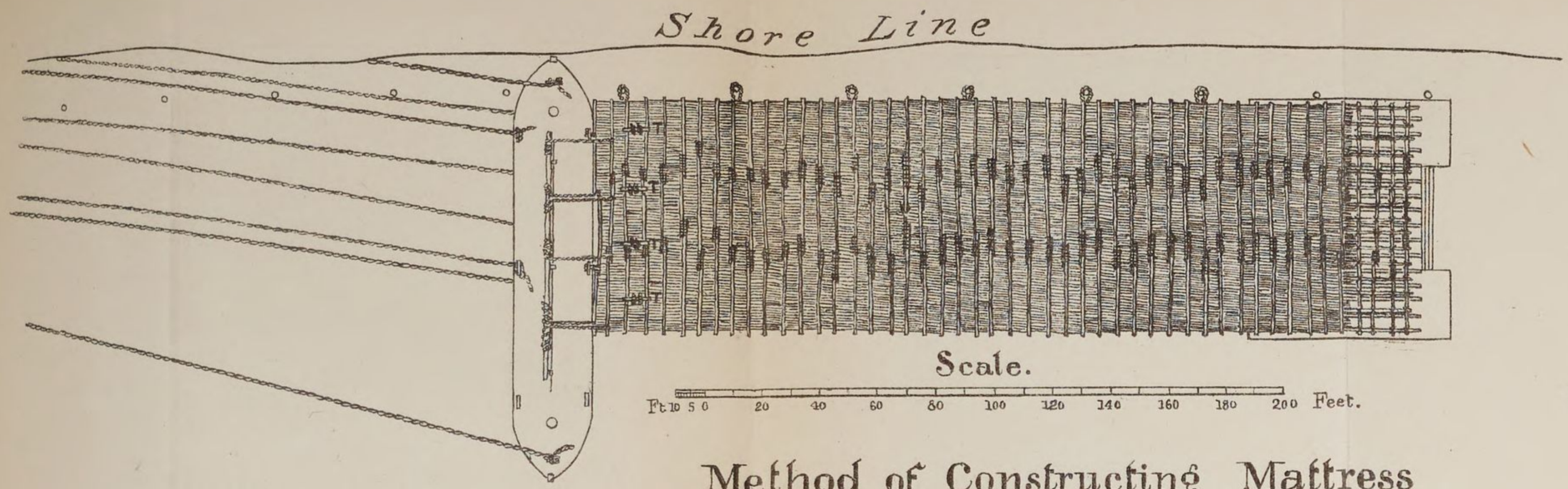
Fall 1878.

Spring 1879.

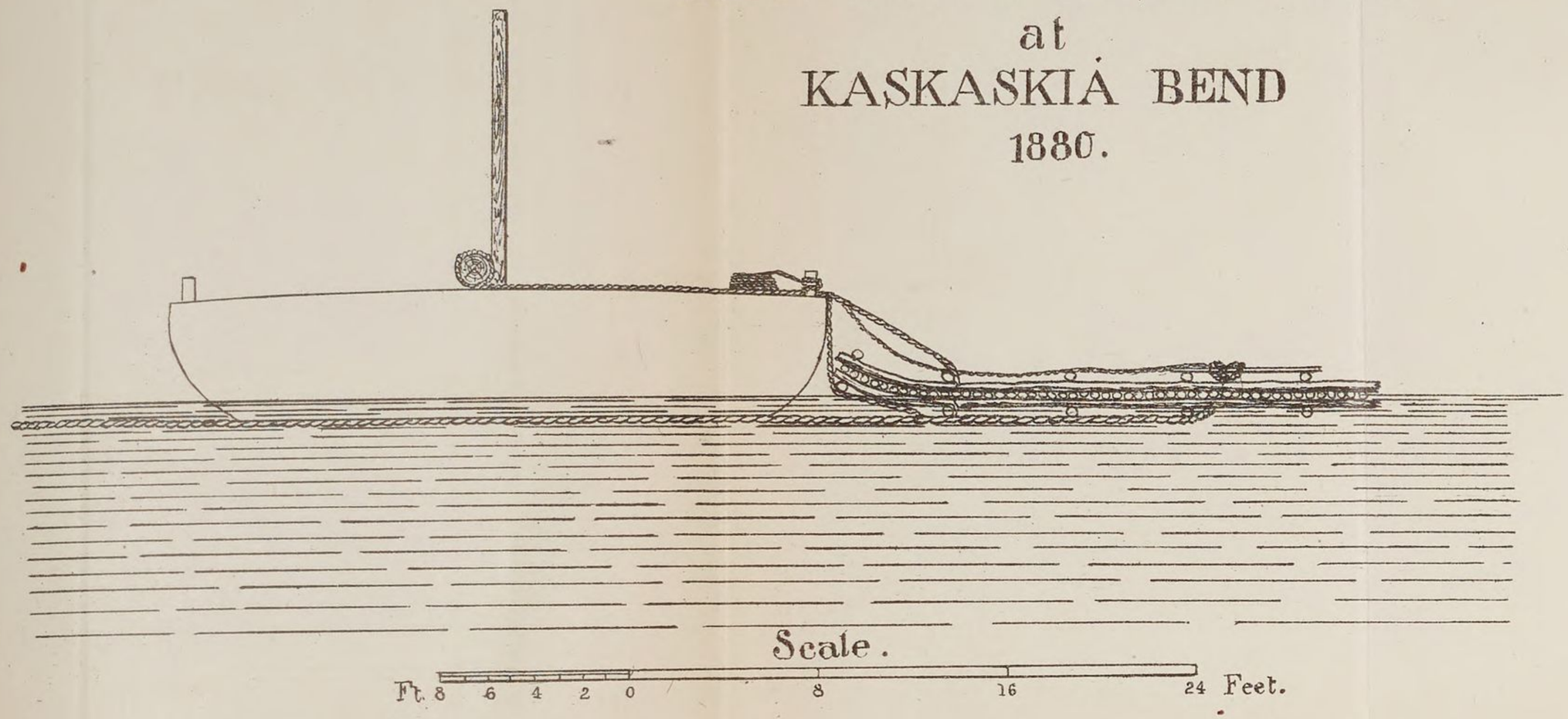
Fall 1879.

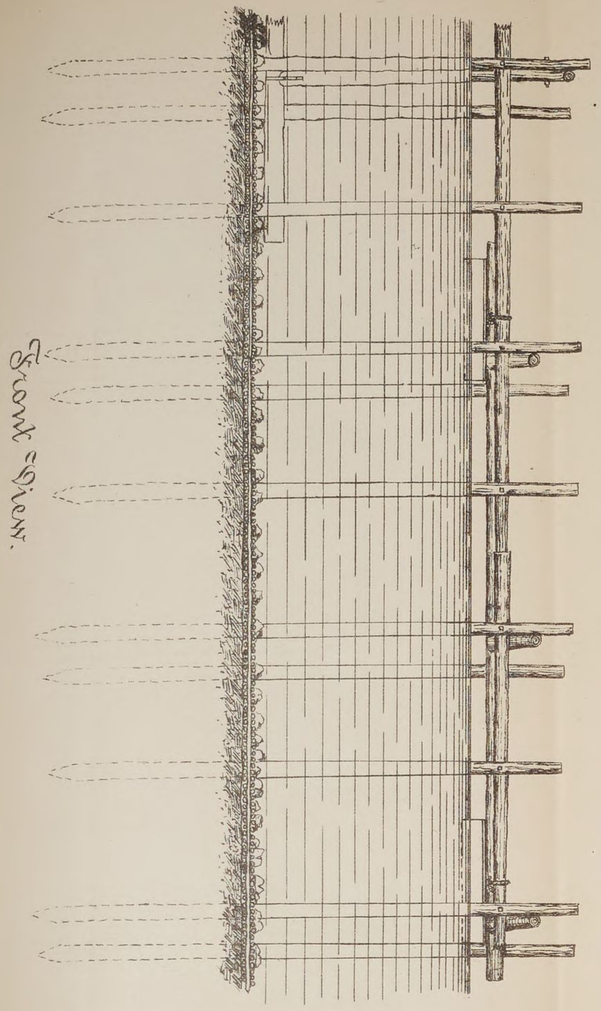
Fall 1880.

Scale.

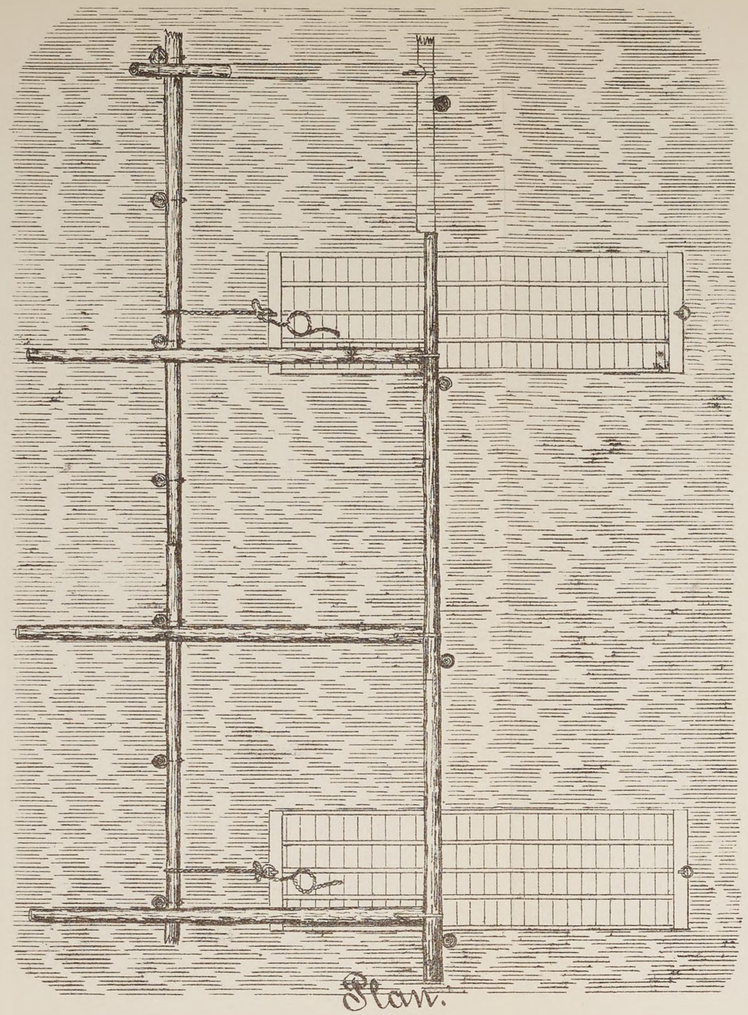


Method of Constructing Mattress
for
SHORE PROTECTION, 80 FT. WIDE
at
KASKASKIA BEND
1880.





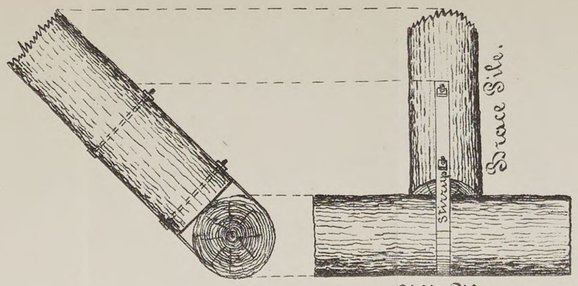
Front View.



Plan.

Scale.

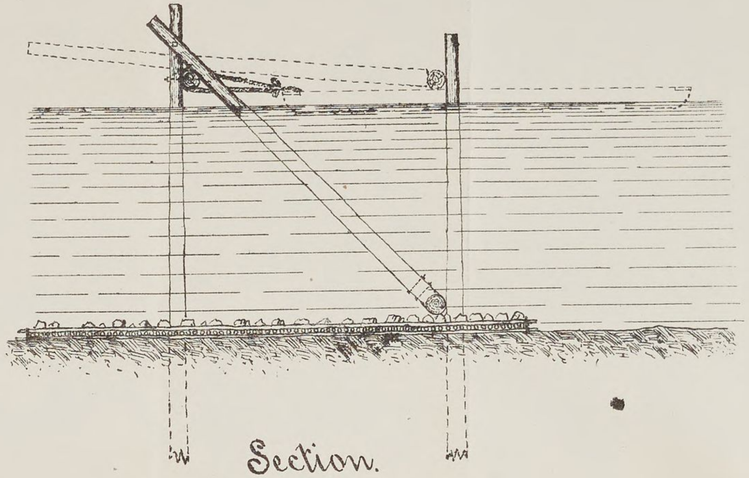
Ft. 10 5 0 10 20 30 40 50 Feet.



Mode of fastening Brace to Sill Pile.

Scale.

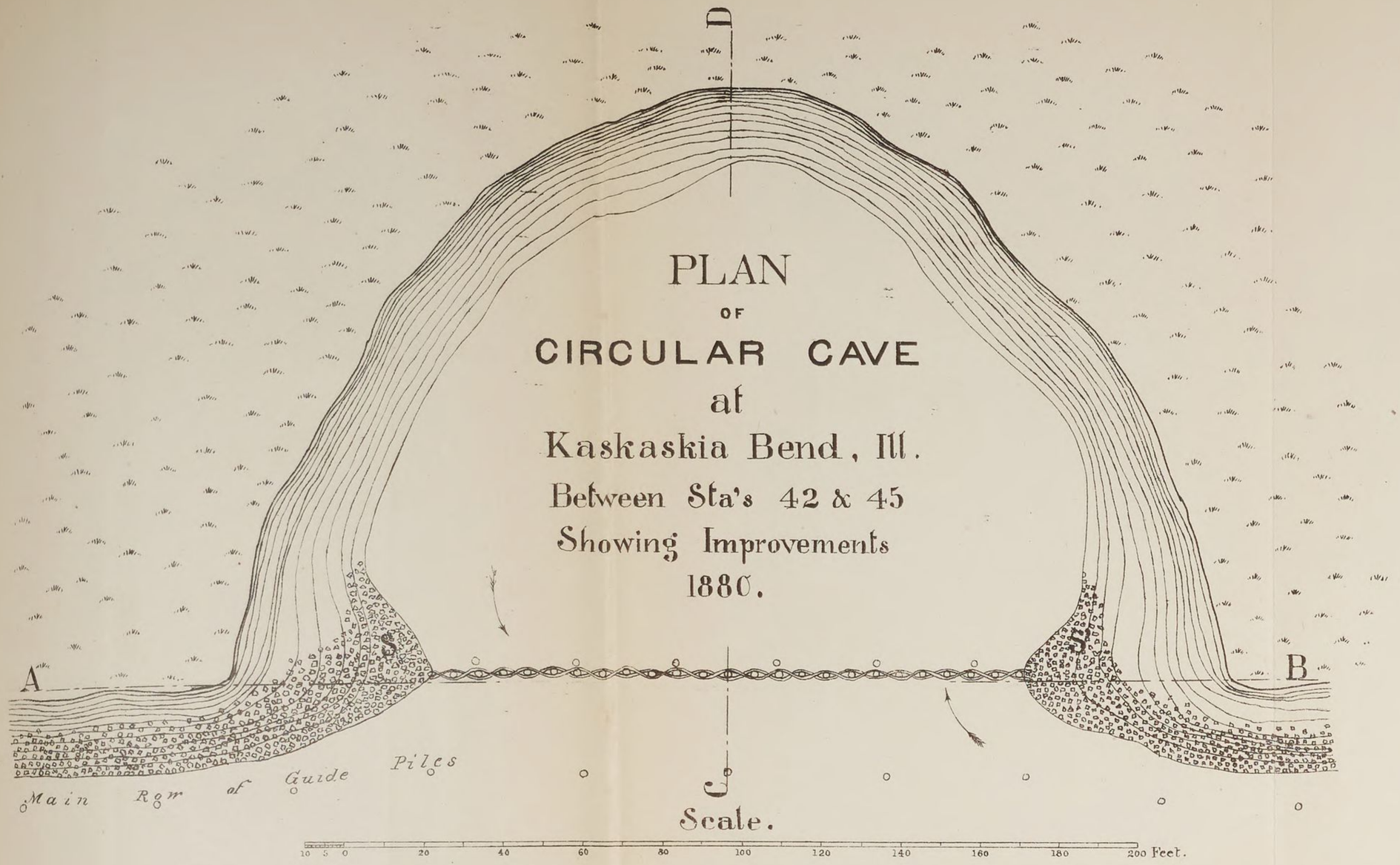
Inches 12 6 0 1 2 3 4 5 Feet.



Section.

Plate No. 17.

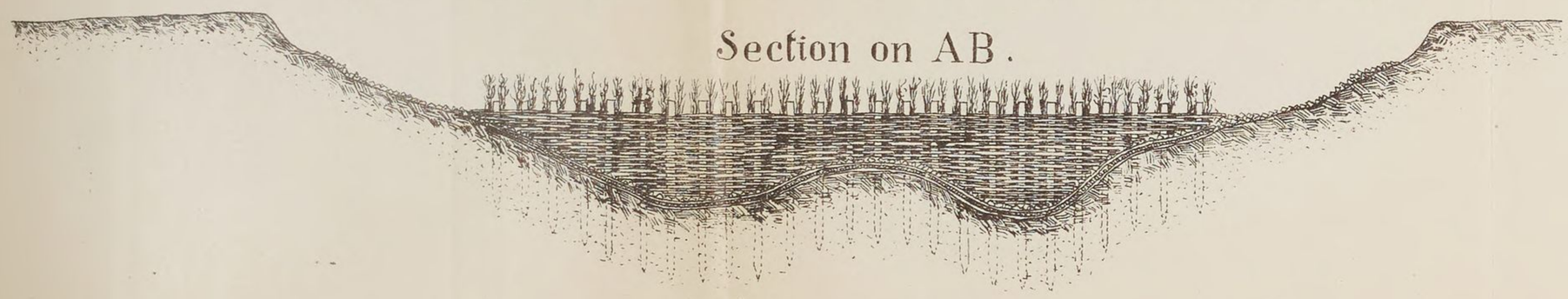
PLAN
OF
CIRCULAR CAVE
at
Kaskaskia Bend, Ill.
Between Sta's 42 & 45
Showing Improvements
1880.



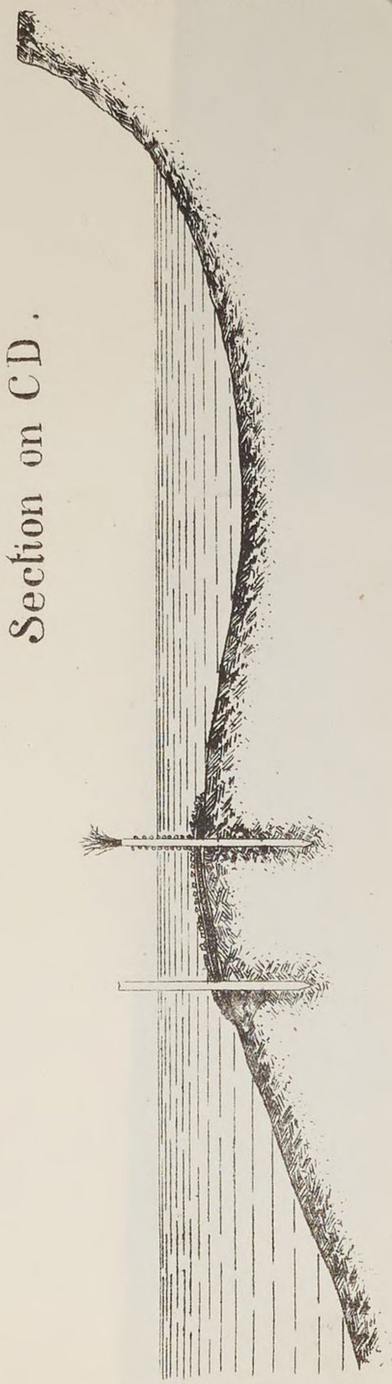
Scale.

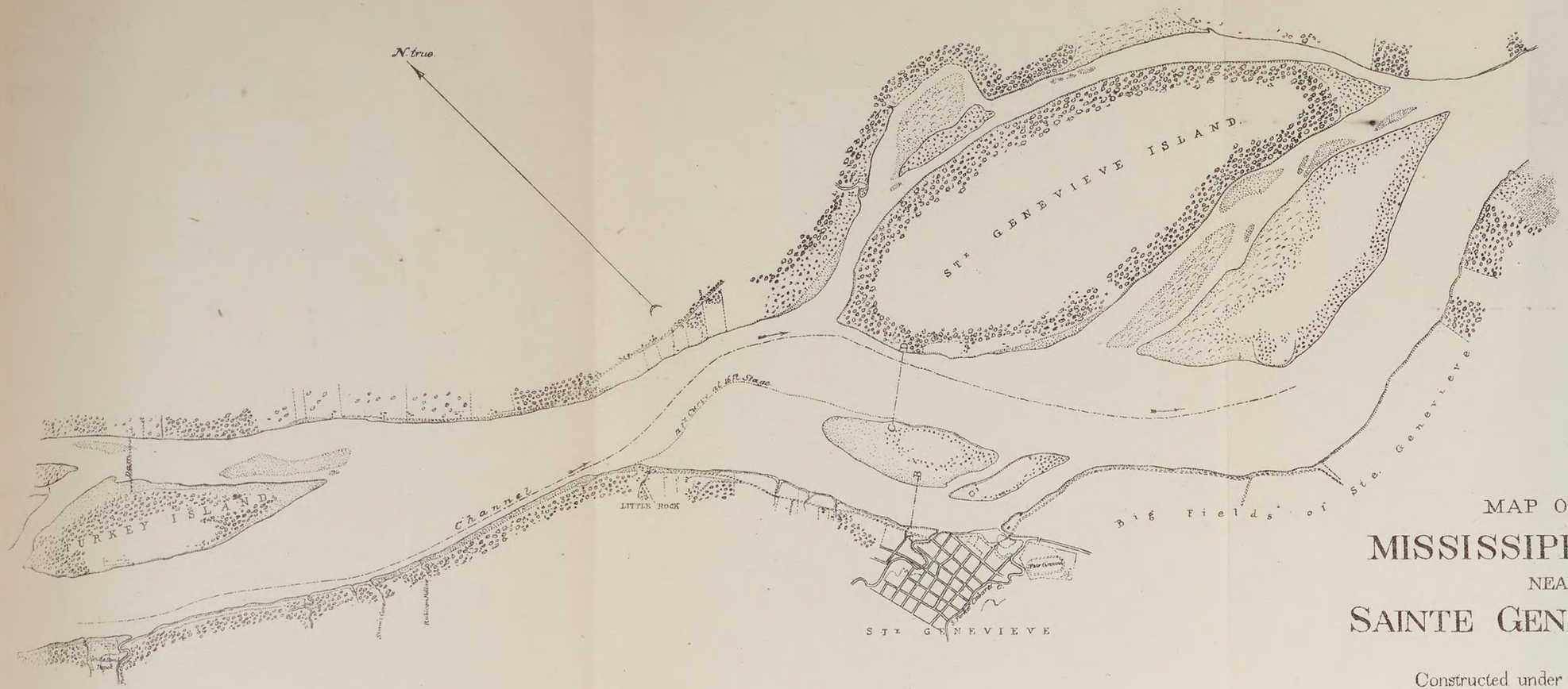
10 5 0 20 40 60 80 100 120 140 160 180 200 Feet.

Section on AB.



Section on CD.





Section on AB

Section on CD

Horizontal Scale 1/5000
Verfical " 1/500

MAP OF THE

MISSISSIPPI RIVER

NEAR

SAINTE GENEVIEVE MO.

Constructed under the direction of

CAPT. O. H. ERNST

Corps of Engineers

From a survey made in April and May 1880

by P. C. F. West, Asst. Eng'r.

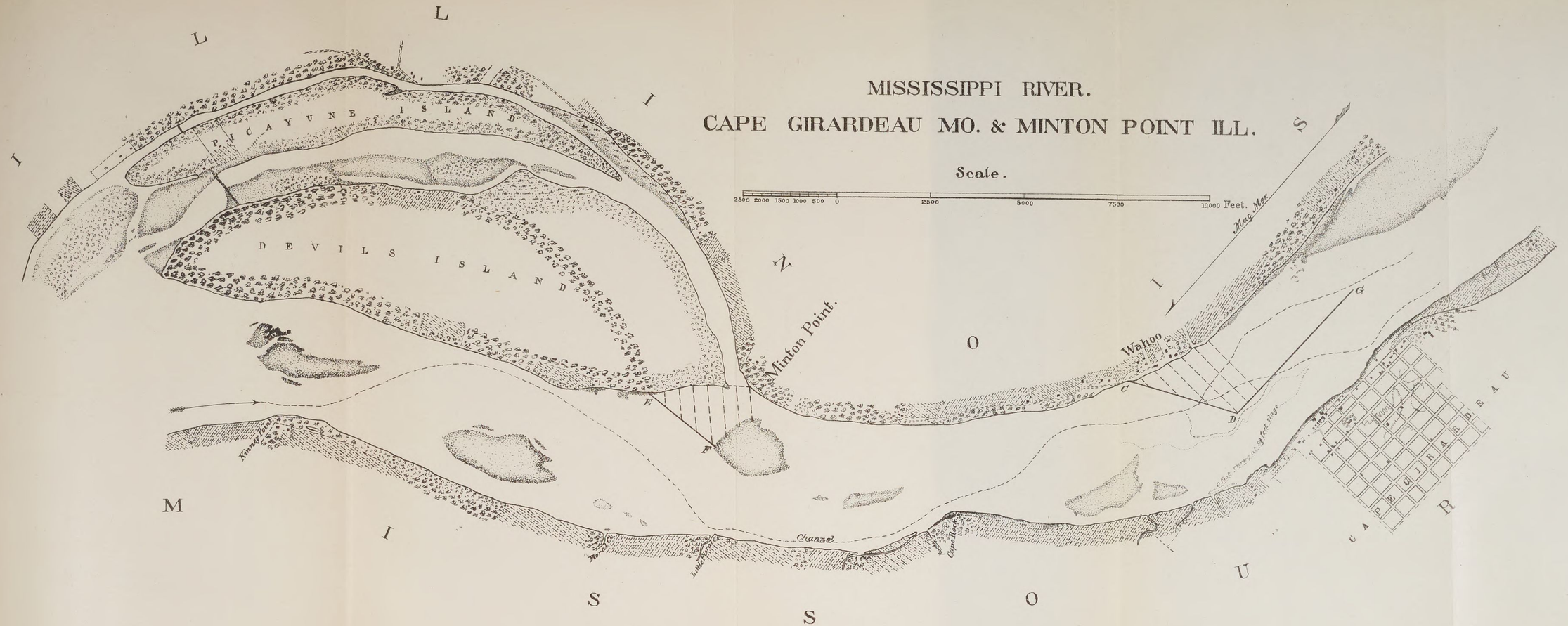
Scale of feet

10 5 0 1 2 3 4 5 6 7 8 9 10 11 12 Thousand feet

Saint Louis Mo. Dec. 6, 1880.
Respectfully forwarded to Chief of Engineers,
with letter of this date.

O. H. Ernst
Captain of Engineers


D .


MISSISSIPPI RIVER.
CAPE GIRARDEAU MO. & MINTON POINT ILL.
Scale.
2500 2000 1500 1000 500 0 2500 5000 7500 10000 Feet.
PICAYUNE ISLAND
DEVILS ISLAND
Minton Point.
Wahoo
Mag. Mer
Channel
CAPE GIRARDEAU
ILLINOIS
MISSISSIPPI

APPENDIX S.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI AND MISSOURI RIVERS—SURVEYS AND IMPROVEMENTS AT VARIOUS POINTS ON MISSOURI RIVER—SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY.

REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., September 28, 1881.

GENERAL: I beg leave to submit herewith my annual report upon the operations committed to my charge during the fiscal year ending June 30, 1881.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

NOTE.—The maps, diagrams, &c., referred to in this appendix were received at the office of the Chief of Engineers too late to be printed.

S 1.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

Work on this improvement was carried on by the four snag-boats, J. N. Macomb, H. G. Wright, R. E. De Russy, and C. B. Reese, the latter being exclusively employed on the Arkansas.

Work on the Mississippi and Missouri began as soon as the appropriation was available, that is in the latter part of August, and was continued as needed throughout the season, except when ice or high-water put a stop to all operations. A total of thirteen and one-half months' snag-boat work was done under my direction, five and three-fourths months on the Mississippi, four and three-fourths months on the Missouri, and three months on the Arkansas. The field operations embraced a total length of 1,484 miles of river; viz, 1,000 miles on the Mississippi, 375 miles on the Missouri, and 109 miles on the Arkansas. The work, though seriously interfered with by unusual floods and a winter of exceptional length and severity, was on the whole satisfactory.

MISSISSIPPI RIVER.

Work on this stream extended from the mouth of the Missouri to the head of Deadman's Bend, a distance of 1,000 miles.

The snag-boat Macomb left Mound City, Ill., August 26, and worked up to Saint Louis and back. On September 10 she went below Cairo, worked down to Memphis and back, and then worked up to Saint Louis, reaching there on September 29. After a short season in the Missouri she resumed operations in the Mississippi at Saint Louis on November 4, and worked down to Rosedale Landing. From this point she returned to Mound City, Ill., and was laid up December 29, 1880.

The snag-boat De Russy left Mound City August 21, 1880, and worked up to Saint Louis. After a short season in the Missouri River she resumed work in the Mississippi September 17, and worked down to the head of Deadman's Bend, 27 miles below Natchez, Miss. From this point she worked back to Cairo, and was laid up November 30, 1880.

Table of work done in Mississippi River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 lbs.	Number of trees cut.	Number of drift piles removed.	Number of miles run.
R. E. De Russy	447	4,489.2	307	4	1,967
H. G. Wright	4	51.5			162
J. N. Macomb	606	9,981.0	340	2	2,279
Total	1,057	14,521.7	647	6	4,408

ESTIMATE.

For repairing one wooden snag-boat and fitting it up for wrecking purposes.	$50,000
For working expenses of three boats, ten months each, at $4,000 per month..	120,000
Total	170,000

Money statement.

July 1, 1880, amount available	$101,404 90	
Amount received (clerical error in accounts rendered)	27 00	
Amount appropriated by act approved March 3, 1881	80,000 00	
		$181,431 90
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		102,308 43
July 1, 1881, amount available		79,123 47

MISSOURI RIVER.

The snag-boat De Russy entered this stream August 27, 1880, and remained there till September 17. The rapidly falling river then compelled her withdrawal. On September 29 the snag-boat Macomb entered the Missouri and remained there till November 4. She was then obliged to withdraw, having worked up as far as Barkersville, 136 miles. The snag-boat H. G. Wright was completed and left Mound City for the Missouri River March 31, 1881. She entered that stream April 11 and has been at work there ever since. Her operations have been confined to the portion of the river below Kansas City, and it is intended to keep her there till the close of navigation. Up to the close of the fiscal year her operations had been materially interfered with by high-water.

Table of work done in the Missouri River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 lbs.	Number of trees cut.	Number of drift piles removed.	Number of miles run.
R. E. De Russy	263	2,137.3	192	12	205
H. G. Wright	521	6,470.5	2,221	5	909
J. N. Macomb	238	2,951.6	.....	8	335
Total	1,022	11,559.4	2,413	25	1,449

ESTIMATE.

For completing the construction of snag-boat now authorized	$25,000 00
For building light-draught snag-boat	80,000 00
For operating three boats, nine months each, at $4,000 per month	108,000 00
Total	213,000 00

Money statement.

July 1, 1880, amount available	$66,041 48	
Amount appropriated by act approved March 3, 1881	80,000 00	
		$146,041 48
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		66,041 48
July 1, 1881, amount available		80,000 00

ARKANSAS RIVER.

The snag-boat C. B. Reese left Mound City November 4, 1880, and entered Arkansas River November 9. From this date till February 1, 1881, she was actively engaged and did excellent work on the lower 109 miles of the river.

On February 1 this boat, together with all the works of improvement on Arkansas River, was turned over to Capt. Thomas H. Handbury, Corps of Engineers, U. S. A.

Table of work done in Arkansas River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 lbs.	Number of trees cut.	Number of drift piles removed.	Number of miles run.
C. B. Reese	572	10,685.5	1,068	21	609

Recapitulation of work done during the fiscal year ending June 30, 1881.

Name of river.	Number of snags pulled.	Weight in tons of 2,000 lbs.	Number of trees cut.	Number of drift piles removed.	Number of miles run.
Mississippi River	1,057	14,521.7	647	6	4,408
Missouri River	1,022	11,559.4	2,413	25	1,449
Arkansas River	572	10,685.5	1,068	21	609
Total	2,651	36,766.6	4,128	52	6,466

Summary of work done on the Mississippi, Missouri, and Arkansas rivers by the United States snag-boats, from March 28, 1868, to June 30, 1881 (on Arkansas River to January 31, 1881).

Name of river.	Number of snags pulled.	Number of trees cut.	Number of drift piles removed.
Mississippi River	14,582	54,605	107
Missouri River	13,309	47,042	335
Arkansas River	5,083	8,059	76
Total	32,974	109,706	518

CONSTRUCTION OF NEW SNAG-BOATS.

After many vexatious delays the new iron snag-boat H. G. Wright was finally completed December 23, 1880. By this time winter had set in and it was not possible to fully test the vessel before the end of March. She was then put in commission and has been at work ever since, fully justifying by her efficient performance my most sanguine expectations. The boat is 187 feet in length by 62 feet beam, and draws when in working trim 30 inches of water. She is 12 feet longer than the Macomb, but otherwise is quite similar to that boat in the general arrangement of hull and machinery. She, however, draws a foot less water, an item of the highest importance. This was effected by a careful pruning of superfluous weights in hull and machinery, by the adoption for the hull of the longitudinal system of framing, and by a slight increase in length of hull. The result is that the new boat, although the larger of the two, weighs with crew, stores, and fuel aboard, with steam up and fully equipped for work, 750 tons, against 930 tons, the corresponding weight of the Macomb, a difference of 180 tons. This excellent result was due to additional experience in this style of construction, to careful study and full preparation of plans, and to great excellence and precision of workmanship in the construction of the hull. It was not attended by any sacrifice whatever, either of strength or efficiency.

The experience with the Macomb fully demonstrates the wisdom of the policy adopted of using iron exclusively in the construction of the hulls of these boats. During the past season the boat was taken out on the ways with a view to inspecting her hull thoroughly, she having then been in the water for six years, and nearly all the time in active and very arduous service. This inspection showed the hull to be in excellent condition, the wasting of the iron plating by oxidation being too small to be appreciable. During this period, which the year just past extends to seven years, all damages to the hull incident to the peculiar service in which she has been engaged have been readily and promptly repaired by the crew, temporarily in the field, and permanently whenever a convenient opportunity offered, with scarcely the loss of a day's service from this cause. The only item specially chargeable to repairs has been for the paint required to keep the iron protected from oxidation. The whole cost of repairs to hull has not averaged over $500 per annum, and the boat is now as good as ever, with nothing to indicate, as yet, when deterioration will begin to be perceptible. The wooden boats which these iron vessels have superseded required annually from $5,000 to $6,000 to keep them in repair, with an additional charge, nearly equal to their first cost, required at the end of five years' service to enable them to last ten years, at the end of which period reconstruction would be absolutely necessary. In other words the expense of building a

wooden boat and keeping her efficient for service during a period of ten years would amount to nearly two and a half times her first cost, while at the end of that time all except her machinery would have to be replaced. On the other hand to build and maintain an iron boat for the same period of time would cost about an equal amount, but the value of the boat would not have been appreciably diminished, and she would still be good for many years of efficient service. This calculation takes account only of actual cost, while there still remains to the credit of the iron boat the lightness of draught and great structural strength, only attainable by this method of construction, the almost perfect immunity from serious damage, or total loss by sinking or burning, and the facility with which repairs can be effected without taking the boat from her work or incurring the expense of docking, inevitably required in the case of a wooden boat; moreover, at the end of four or five years the draught of a wooden boat will have increased a foot at least by water soaking, while that of an iron-boat will have remained unchanged. It should be stated here that the dimensions adopted for the *Macomb* and the *Wright* were such as were suitable to machinery that we had on hand, but smaller boats with lighter machinery would have been better and cheaper both in first cost and in cost of operating. Such a boat will be built this year, as soon as the plans can be matured, designed especially for the Missouri River. This boat will have the same length as the *Wright*, but 10 feet less beam. Her draught will probably be somewhat less, while the reduction of beam will be practically equivalent to a diminished draught of 3 or 4 inches when it is a question of running a narrow channel. The working machinery will be identical with that on the larger boats. This boat will probably be completed in the fall of 1882, provided the amount, $25,000, deemed necessary in addition to the present appropriation of $80,000, be available in time to avoid delay in the construction and finishing of the boat.

When this boat is completed we will have three first class snag-boats, which will probably suffice for the Mississippi and Lower Missouri, but there is still a large field for work on the Upper Missouri which none of these large boats can reach. As the trade of this part of the river is of very great importance it is proper that its wants in this respect should be met, and for this purpose I recommend the construction of a stern-wheel snag-boat similar to the C. B. Reese and J. R. Meigs. The estimated cost of such a boat is $80,000, and its construction should be undertaken as soon as possible.

There still remains the wooden snag-boat R. E. De Russy, which I have been obliged to keep at snag-boat work, although she is no longer fit for such service even with heavy annual repairs. I propose at the first opportunity to thoroughly repair her and fit her up as a wrecking boat, there being a vast amount of work on hand for a boat of this description. The estimate for this purpose is $50,000.

OPERATIONS FOR THE COMING SEASON.

The plans submitted to you contemplate the partial construction of the Missouri River snag-boat, current repairs to the rest of the fleet, and twenty months' snag-boat work upon the Mississippi. Eight months' snag-boat work will be done upon the Missouri River, the expense being defrayed by the appropriation for improving Missouri River from Kansas City to its mouth.

The work is situated in the collection district of New Orleans.

The amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

The commerce benefited by the work is that of the entire Mississippi Valley.

S 2.

IMPROVEMENT OF MISSOURI RIVER AT SAINT CHARLES, MISSOURI.

During the past season the projected improvement in this vicinity was begun. Plans for carrying on the work were decided on, and progress made in the collection of plant. Work was begun in the spring, and though much delayed and impeded by high-water, has made good progress.

The chute behind Saint Charles Island has been closed by a wire-screen dike, and other dikes, both floating and supported on piles, have been constructed at the head of the island and at Downing's Point on the right bank.

The object sought is the contraction of the river bed to certain definite and uniform limits and the guiding of the channel into such a course as will best subserve both the general and local interests, more particularly with regard to the approach to the Saint Charles Bridge.

This work is still in progress. Later in the season the lower end of Saint Charles Bend will be revetted, and in the coming spring dike-work will be continued.

The estimate for this work has been revised and extended.

Operations at this point have been in charge of Assistant L. E. Cooley.

This work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$25,000 00	
Amount received from sale of fuel to officers	73 12	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$40,073 12
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		24,191 81
July 1, 1881, amount available		15,881 31
Amount (estimated) required for completion of existing project		250,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		60,000 00

REPORT OF MR. L. E. COOLEY, ASSISTANT ENGINEER.

SAINT CHARLES MO., *July* 16, 1881.

MAJOR: Under date of August 12, 1880, I was assigned to duty at this point with instructions.

Surveys and investigations of the physical features of this reach were entered upon, and these, with studies in construction, occupied the time of this party during the autumn and winter.

The result of these investigations so far as completed at the time were embraced in a provisional project for improvement, submitted February 24, 1881.

This project contemplated the expenditure of the appropriation then available and the one subsequently available, a total of $40,000, as part of a scheme for the improvement of sufficient river to insure reasonable permanence to the results desired at Saint Charles.

In accordance with circular of June 3, a new estimate was presented on July 2. This, together with the project previously referred to, discusses the characteristics of the reach, and nature and cost of an improvement as fully as is warranted, until the season's work is terminated, and the data collected is fully considered.

During the winter the subject of pile sinking, by means of jets of water, also wire netting as a means of improving the Missouri River, both referred to in my last annual report, were fully considered by boards appointed for the purpose. Their reports discuss these subjects so fully that little remains to be said, except as to the general results of the season's experience.

The collection and construction of plant was commenced in February, and matters were so far advanced that construction could have begun by April 1 had the machinery required come duly to hand.

Our plans also contemplated the use of a tug. This arrived in ample season, but as she proved inefficient her services were dipensed with early in June. As our material had been delivered at points unfavorable for cordeling, this proved very vexatious, and caused much delay and expense.

The machinery finally arrived late in May, and the trial or experimental stage was reduced to a working basis about the middle of June.

Meantime efforts were limited to expedients, viz: buoy dikes in unsuitable locations, and pile sinking by a hand-pump, which was inadequate for the heavy work required; still the results were encouraging, considering the experimental character of the methods, but they were obtained at incommensurate expense.

The work placed in the last few weeks and the methods adopted are showing very favorable results, but it is yet too soon to speak confidently.

The plant consists of six-decked barges, 60 by 15 by 3 feet, one of which is used as a tool or store boat, having a house 18 by 44 feet, three smaller barges, a number of small flats and skiffs, wire-net machine, pile-sinking machinery, and a miscellaneous collection of devices and tools. The pile-sinking device is essentially temporary.

The argillaceous stratification in this portion of the valley caused some doubts as to the efficiency of the board's design at this point, which, coupled with our desire to get to work without further delay, determined us to adopt expedients until our experience was better matured.

To this time the wisdom of our course would seem evident, as radical changes will acquire working out to fully adapt the process to strata which are not tolerably free sand or recent silt.

The boiler, pump, and windlass, as well as the method of applying the water, are essentially that of the Board. An ordinary boom derrick handles the pile; the pile is controlled in its descent from an overhead platform, and within the angle of an L, formed by two barges, the machinery or derrick barge 60 by 15 by 3 feet, and the cross or platform barge 36 by 10 by 3 feet. No guides or cradles are employed.

In free material a penetration of 18 feet has been attained without special difficulty. Gravel of 1 or 2 inches in diameter soon arrests the descent, while clay strata of 6 inches to 1 foot are difficult to overcome. The clay strata referred to in project as being continuous at or about low-water plane, with admixtures of clay still lower, are fully confirmed, these constituting definite horizons at which the descent is usually arrested.

It is believed that the limitations of the present device will be fully understood, and that in a future apparatus we shall be able to contend better with these conditions, which are not presented in the upper stream, and which geological reasons would confine most largely to the valley below the basins of the Osage and Gasconade.

The netting device is a development of one of the designs of my assistant, Mr. F. M. Harris, described in a paper appended to the report of the Board on "wire netting," &c. It consists of a skeleton drum with studs, about which the wire is looped and twisted in a pin twist, meshes square or trapezoidal, and of 1 foot area. The device was constructed experimentally and considerable stock net made. It was afterwards placed on a boat, where it is now weaving a screen 60 feet wide, and placing it direct as made along a pile support. A speed of 300 feet per day has been obtained, and, with requisite skill and special adaptations in devices, it is believed that a rate of 1 foot per minute is entirely feasible in meshes of 1 foot area.

The work attempted previous to the great rise of May 5 consisted of a few sections of buoyed screen only. For nearly a fortnight thereafter the banks were in such a condition as to make work impracticable without the services of a tug. A buoyed sectional dike, 600 feet long, immediately above the head of the slough, was placed in water 30 to 45 feet deep. This was quickly submerged and apparently destroyed by drift, but its effect was to cause a rapid bottom fill in the vicinity, and a shifting of the line of deepest water by half the width of the stream.

Meantime a line of work 500 feet long was placed across the slough, about 1,000 feet below its head. Piles were sunk by a hand pump, where the depth was available.

About one-third of the dike consisted of triangular pyramids of piling placed in 26 feet of water. The whole was covered with stock screen.

The resistance gradually increased until a dead head of about a foot was attained. A rise of a couple of feet from a tributary caused an immense accumulation of surface drift against the tops of the tripods, which from deficient weighting were overturned.

This was repaired, but, the action continuing, the dike was abandoned, although it

is believed that a persistent following up, even with these means, would ultimately have produced the desired effect. The remaining two-thirds of the work was effected in causing deposits.

The machinery arriving in the last of May, a new pile-dike was commenced across the head of the slough, 1,150 feet long.

As the net-boat did not at first work satisfactorily, the piles were driven before much progress had been made in placing the screen, and the pile-boat was moored to the head of the reach to commence the project proper, sufficient resources not being available at an earlier date.

Before the dike could be completed, large and deep drift accumulation took place against the unprotected face of the piling, causing bottom scour, and a considerable section was turned out. The remainder was secured, and the plant transferred to the upper work.

It was intended to retain a few men here to make needed repairs, but labor has been so scarce and of such a character that it has been impossible to do so, and the slough work yet remains in an unfinished condition.

The effect of the work has, however, been exceedingly good, and our experience leads us to believe that the most difficult problem of slough closure may be handled successfully and at reasonable cost, a matter of which I was previously in great doubt.

The main line work, leading down some 4,000 feet from Downing's Point, with its system of cross-dikes, is more than half completed. It is intended to complete this, and then return to work in the vicinity of the slough, the contrary flexion already produced in the stream at this point arguing favorable results, the depth being reduced to that amount which caused the grounding of a steamer on the 13th instant. The slough itself will be further treated for present results, and with a view of causing its more complete setting next season.

The erosion above the head of the slough is approaching the curvature desired for bend No. 1, and will probably admit revetment this season. In this event the work promises to accomplish fairly and in part what had been hoped for the season's operations, and place the stream in excellent shape for early spring work should an appropriation be available.

The coming spring work will produce the first effects in Saint Charles Bend proper, and effects are likely to be radical if matters can be followed up in proper time.

The work this season could readily have produced twice the results had it been possible to make the plant available forty-five days sooner. This will not prove a detriment in future, as much necessary plant has been provided; still a considerable increase will be required for most effective results.

The necessity of adequate appropriations and a prompt treatment for this reach is apparent. It is believed that nothing but a constitutional treatment is admissible, and that work placed in Saint Charles Bend in advance of radical change above will be disappointing in results and waste funds in a local treatment that could as soon or sooner produce a permanent effect if expended in the main project.

The experience of the year has been very fruitful and suggestive, but as we are in the midst of operations it does not seem wise to go now into the details of methods or elaborate the results, practical and theoretical.

When operations are closed I shall expect to submit a detailed and illustrated report, in which I shall consider fully all information and data of general interest, and conclusions as to the present and future development of the class of constructions now inaugurated.

I am, Major, very respectfully, your obedient servant,

L. E. COOLEY.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 3.

IMPROVEMENT OF MISSOURI RIVER AT CEDAR CITY, MISSOURI.

Work was resumed at this point early in the spring, with Assistant T. C. Bradley in local charge. The object in view was silting up Cedar City Bend. This had been previously attempted, a permeable dike of Brownlow weeds being used, but without success. This year a wire screen dike was used, the meshes of the screen being rectangular, 2 feet long and 1 foot high. They were supported on tripods or buoys at first and later on pile bents. The work had the benefit of the high-water and

was eminently successful, the whole space between the dike and the bank being filled about to high-water mark; the deposit was 20 feet in average depth over an area of about 12,000 square feet. During the present season it is proposed to begin work in Murray's Bend above Cedar City, in accordance with the approved plan. A revision and extension of the estimates for this work has been found necessary.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$15,413 97	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$30,413 97
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		13,576 78
July 1, 1881, amount available		16,837 19
Amount (estimated) required for completion of existing project		170,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		60,000 00

REPORT OF MR. T. C. BRADLEY, ASSISTANT ENGINEER.

CEDAR CITY, MO., *July* 13, 1881.

MAJOR: I have the honor to submit herewith the following annual report of operations for the fiscal year ending June 30, 1881. The work has been carried on under approved project of March 21, 1881, which aims at general rectification of the river between Stanley's Island and Jefferson City. The objective points of improvement are at Cedar City and in Murray's Bend.

The danger at Cedar City dates back to 1876, when the left bank of the river began caving just above the mouth of Cedar Creek. This action has continued ever since developing what is now known as Cedar Creek Bend. Three attempts at improvement in the vicinity of Cedar City have been made at various times by the citizens.

The first was a solid stone dike located just below Claysville. It was designed to force a crossing through a high-water chute to the right of the Murray Bend sand-bar. It was thought that by this means the valuable bottom lands in the Murray Bend crossing could be saved. This work was estimated to cost $20,000, but only $14,000 were raised. About 200 feet of this dike still exists, and is a dangerous obstruction to navigation; the eddy action above and below is quite pronounced. A government light marks its location.

The next attempt at improvement was made in the immediate vicinity of Cedar City. A tree dike was placed at the head of the bend in the summer of 1876. The position of this dike was similar to the Brownlow weed dike placed under your direction in 1879. It failed, however, to secure any permanent advantage, and the channel continued to take Cedar Creek Bend.

The next attempt was made by the citizens in the fall of 1877. The work consisted of mattress work protecting the left bank of Cedar Creek immediately in front of the town. The mattress was made in sections 50 by 40 feet and shingled down stream. They were made of willows secured between heavy pole stringers. The mat was given an average thickness of 20 inches and the sections were sunk under great quantities of rock. This work seems to have held at Cedar City Point, but above there was nothing to indicate that mattress work had been put in in 1879. Considering the small width, rigidity, and the great quantities of rock used, it is not improbable that the whole system slid into the channel.

The mattress work and Cedar City dike placed under your direction have already been reported on. It may be proper to state that the mattress work has stood two years and is now in good condition. It stood the test of last winter under the influence of moving ice, and a still greater test during the April flood of 1881. The only damage was that done to the high-water protection at the point, a scour 4 feet deep and about 100 feet square.

It was the intention to begin work of construction early in the spring in order to get

the benefit of the April as well as the June rise, but the unusual severity of the winter seriously interfered. Repairs on boats and plant were not completed until April 1.

On April 13 preparations were made to begin the work of placing the screen dike in Cedar Creek Bend under approved project of March 21, 1881. On the 22d it became necessary to suspend work on account of high-water and drift. Operations were entirely suspended until May 11, the water reaching its highest point May 3, when it marked 99.65 on the Cedar City gauge. The work was resumed May 11.

The screen dike as contemplated in project is 1,000 feet of cross dike, and 3,000 feet of trailing dike, suspended on tripod supports. The depth of the screen is equal to twice the depth and is suspended on the upper side of the dike. The tripods were made of hard wood poles 25 feet long and 6 inches in diameter at the butt. The base consists of three poles forming an equilateral triangle securely bound with number 8 wire; 3 poles are laid parallel and wired together at a distance of 23 feet from the butts. These 3 poles complete the tripod by securing a pole at the butt in each angle of the base. For anchorage ¾ yards of rock secured at each corner of the base is used. A net 6 feet square (haxagonal mesh) with an 8-inch diagonal serves as an inclosure for rock. This net has free angles on all its sides which resemble saw teeth. The leg of the tripod is passed through the center mesh and the four corners of the net brought together around the tripod leg. The rock is then put in and inclosed by joining the free angles of adjacent sides by pin twist. This method is found cheaper than baling rock, and it admits of the use of small rock. The cost of manufacture is 4 cents per net. This tripod is constructed on the derrick barge and swung off and lowered into position by means of a derrick. The tripod support is not one of great merit, and must be regarded only as an expedient.

When the work will warrant a more expensive plant, more efficient methods can be employed, such as piling in A bents sunk by hydraulic jet. The tripod is nevertheless an efficient and economical construction in depths of water not exceeding 17 feet; beyond this other methods must be resorted to. These tripods were placed on the line of the deposed dike 20 feet apart, and the whole system connected by a wire rope to which the air edge of the screen is attached. The wire netting is made on a frame in sections 70 feet by 20 feet. The mesh is rectangular, 1 foot on the vertical by 2 feet on the horizontal. This is found to be the best size for an average depth of 18 feet. A mesh 1 foot square was tried, but it was found to collect fibrous matter too rapidly, or rather before deposit had re-enforced the screen. Rupture did not take place in the netting, but the tripods overturned. A mesh 2 feet square was tried, but its action was too slow. The screen was suspended to supports and placed in position from two boats, which were moved down the line of the dike as fast as the air edge could be secured, and anchors which were baled to the lower edge could be paid off the side.

The anchors were guided to position by a trailing boom. When a depth of 23 feet of water was reached, barrel buoys were resorted to for supports. Screens in sections 70 by 40 feet were placed normal to the current and shingling down stream. These were placed as follows: A boat 70 feet long was used with a shelf 2 feet in width hinged to one side and running the entire length of the boat. Upon this shelf the anchors were laid and secured to one edge of the screen. The netting was then folded on these anchors so as to straighten out readily in the water, and the buoys were attached to the other edge of the screen. To prevent collapse and scallops a rigid waling was placed on anchor and buoy edge of the screen, by lashing poles together. The screen thus prepared, the boat is moved to position and the shelf dropped, allowing the screen to assume the desired position. No difficulty is experienced in placing this screen in any desired position. It is very uncertain in its action, and will be just so long as an efficient and economical buoy remains an unsolved problem. Oil-barrel buoys were used, and it is believed that they have given better results than any other form.

The action of the screen dike has been quite marked. The outer 500 feet of cross dike was placed in water from 10 to 15 feet deep. The depth of water on the first 1,500 feet increased gradually from 15 to 23 feet. This latter depth has been pushed down stream as the work progressed. The increase in the size of wires, due to the accumulation of fibrous matter, was quite noticeable. The Cedar Creek chute has entirely left the bend. The current passing below the lower end of dike takes a direct course for the mouth of Cedar Creek.

By continuing the dike 800 feet farther, it is believed that the channel can be thrown outside of the Cedar City Point.

At this writing a dry bar exists back of the cross dike which extends from the main shore line to the trailing dike and a distance of 3,000 feet down the trail. The bar extends close to the line and shows clearly a deposit of 15 to 23 feet. The results obtained are remarkable, notwithstanding the conditions this spring have been unfavorable for dike work.

The main channel is now clearly defined down the right bank from Gray's Creek to efferson City.

Since the dike work was begun the willow tow-head in the proposed channel just

below end of dike has entirely disappeared. The work of completing dike is still in progress, also the construction of 1,000 feet of revetment between the mouth of Cedar Creek and the abutment.

As the current was thrown out of the bend under the influence of the dike, the water concentrated just above the abutment. Caving action set in, endangering the entire system of mats between the abutment and the Cedar City Point. It was considered important to hold this in any event. The work was put off as long as possible, as it is believed the dike will ultimately throw the current beyond the point, and therefore render revetment unnecessary.

The caving action increased to such an extent that it was thought necessary to put in a light revetment.

The mattress is continuous 75 feet wide, and is essentially a layer of willows 4 inches thick, inclosed between two wire nets made of No. 12 steel wire with a 4-foot square mesh. The willows were first laid parallel to the bank, but as it was found that the mattress contracted in width, the willows were afterwards laid at right angles to the shore line. The mattress is so thin as to be flexible, and it will conform to the irregularities on the bottom as effectually as in the first instance.

The upper net is placed immediately over the lower one, the under wire is brought up and secured to the upper wire every 2 feet by a pin twist. This binds the willows in securely. For lateral longitudinal strength there are two strands of number 12 steel wire every 4 feet. As both the work of dike and mattress construction is only partially completed, it is not possible to get at the cost. It is safe to say that the cost will fall within the estimate. For a clear idea of the methods and appliances you are respectfully referred to maps and photographs.

Before closing, I desire to acknowledge the valuable services rendered by my assistant, Mr. Gotlief Gender. He has manifested commendable zeal and judgment in the discharge of his duties.

I am, Major, very respectfully, your obedient servant,

T. C. BRADLEY,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

S 4.

IMPROVEMENT OF MISSOURI RIVER, AT GLASGOW, MISSOURI.

As soon as the summer flood of 1880 went down it was discovered that the right bank of the river, in the bend above Glasgow, was being so violently attacked by the river as to render its immediate protection imperatively necessary.

Work was therefore begun, and 5,630 feet of bank was covered with a very substantial revetment. The upper bank was graded to a very flat slope, and thatched with brush, which in turn was covered with earth. This work was exposed to the full shock of the moving ice during the spring break-up, and subsequently was in the track of the water, which during the general overflow ran directly across the point. The revetment stood this severe test perfectly, and this part of the work being now considered safe, attention is being directed to other portions of the reach. Dike work will mainly be deferred until spring, but additional revetment is needed at several points, and will be put in during the present season.

The work has been in charge of Assistant S. Waters Fox.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$21,009 82	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$41,009 82
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		25,746 39
July 1, 1881, amount available		15,263 43
Amount (estimated) required for completion of existing project		78,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		78,000 00

REPORT OF MR. S. WATERS FOX, ASSISTANT ENGINEER.

GLASGOW, *July* 14, 1881.

MAJOR: I have the honor to submit the following report of the improvement of the Missouri River, in the vicinity of Glasgow, during the fiscal year ending June 30, 1881. For convenience, it is divided into two parts.

Part 1 embraces operations from July 1, 1880, to April 25, 1881.

Part 2 embraces operations from April 25, 1881, to June 30, 1881.

* * * * * * *

PART I.

A project was submitted June 26, involving the expenditure during that season of $11,775, and recommending that the balance of the appropriation, $8,225, be held for work in the ensuing spring. This project was approved and preparations begun for its execution, but a short time afterwards the river concentrated its flow into No. 4 chute and attacked the right bank, threatening to carry away the Chicago and Alton Railroad track. August 2 I recommended that a continuous brush revetment, commencing at a point 1,600 feet above the old railroad dike, and extending down stream 2,400 feet, be put in as soon as possible. The low-water mat to be not less than 100 feet wide, and connected with a high-water protection laid on a graded slope of 2½ to 1. An entirely inadequate portion of the appropriation was available at that time.

The demands for immediate action were so urgent that our appliances were necessarily crude. The plant was towed into position August 13; grading commenced the 14th, and a start was made on the mattress August 16. As we progressed with the work, the necessity of continuing it beyond the proposed length became apparent.

November 8 the funds were exhausted and work stopped; 6,057 feet of shore had been graded, and of this 5,630 feet had been revetted. In addition 600 feet of willow curtains had been put in as a dike for the protection of the upper end of the mattress.

A number of surveys were made, and some special physical data collected, which are mentioned further on.

REVETMENT.

The mattress boat was a decked flat 100 feet long, 25 feet wide, 4 feet 5½ inches depth of gunwale. This was provided with twenty-one ways, supported on trussed bents, spaced 5 feet from center to center.

From the gunwale back 8 feet their slope was 1 in 3, from there up 1 in 4.

An outrigger extended from the top end of the shore-way 11 feet out, over the end of the boat, thus allowing a foot projection over the outer way; the width of the low-water mat was 112 feet. The average width of high-water protection was 38 feet, making the total average width of revetment 150 feet.

The method of construction of the low-water mat is shown quite clearly by the artotypes submitted. It may be briefly described as follows, viz: a single thickness of brush, laid in juxtaposition across the ways, butts to the bank, was covered with scraggly dogwood, laid with the ways; over this just sufficient brush was laid to hold the dogwood in place; over all, at every way, was a continuous fascine of willows; to each of these the brush was sewn with wire (numbers 8, 10, and 12), by means of two shuttles, making a lockstitch every 3 feet. Thus we made in effect a brush carpet, with a close warp, and an open or cellular woof. The fascines were serviceable in strengthening the mat and in preventing the stone from rolling. The mat was fleeted off the ways by means of two sets of lines and toggles; about one-third cubic yard of broken rock to the linear foot thrown on near the out edge was sufficient to put the mat on the bottom.

The mat was not sunk immediately up to the boat; in some places as much as 600 feet was allowed to float; this accumulated sediment, and thereby effected an economy of stone.

A force of 35 men was required on the boat. A fair day's work was 125 feet linear, or 14,000 square feet.

For the high-water protection brush was shingled on the graded bank parallel to the shore line, the tops down stream and overlapping the butts. No. 8 wires made fast in the low-water mat, 5 feet apart, ran up over the brush to the top of the bank, where they were fastened to stakes 5 feet apart.

Forked stakes were driven over the wires, 5 feet apart up the slope, so as to bind the brush to the ground. The whole was then covered with earth. This covering has proven serviceable in three ways, viz: 1st, as a protection against the sun, rain, and fire; 2d, against the tearing force of ice and drift; 3d, if willow brush is used, it causes them to sprout.

GRADING.

As already stated the bank was graded to a slope of $2\frac{1}{2}$ to 1. It ran on an average 8.8 cubic yards to the foot linear; its composition was of sand and gumbo, varying in proportion from pure gumbo to 90 per cent. sand. The method of moving it first used was with plows and scrapers; this proved very expensive, and it soon became apparent that we would not be able to keep ahead of the mattress boat.

Another consideration which led to the trial of hydraulic grading, was that the steamer Aggie, which had been chartered on the 14th of August, could be kept at work, towing, but a very small portion of her time.

A Worthington duplex pump, special mining pattern, 12-inch steam, 7-inch water cylinders, 10-inch stroke, was put on the *Aggie* and connected with her boilers. August 30, we commenced grading with it, and did the work successfully until the close, November 8, removing in all 43,793 cubic yards.

The method of working is illustrated and described in the appendix.* There are also some tables and plates, showing the performance of the pump, and the cost of moving the material. This latter is the actual necessary cost. That shown in the general "cost exhibit" is larger, from the fact that the time of the steamer Aggie, at $50 per day, was charged to it.

The pump was undoubtedly too small; to do the work it had to be held at a much higher speed than is economical.

One fault in the construction of the pump that should be remedied is that no provision is made for taking up the wear of the plunger rings. In such water as the Missouri they wear in a short time and have to be replaced.

The results of this work clearly indicate that hydraulic grading is by far the cheapest, and in other respects the most desirable method yet practiced.

The minimum cost per cubic yard was .87 cent. I believe that with a more perfect plant, other things remaining the same, this cost may be reduced to one-half cent, or perhaps even less.

WILLOW CURTAINS.

These were made on a boat, 65 by 16 feet, exactly as those described in my report of last year; the stone anchorage was laid in a hem along the ground edge of the curtain, thus: ⌐; the floats were tarred boxes, 12 by 12 inches by 5 feet; the meshes were 4 feet by 10 inches.

The revetment has been subjected to very severe tests by ice and high-water. As far as could be judged by careful probing, it was not injured in the least.

Some time after the commencement of the April rise, Harrison's Island shore line straightened out so as to relieve the pressure on the revetment, and, indeed, a bar formed across the head of No. 4 chute, which almost entirely closed it.

SURVEYS.

During the season the reach was accurately triangulated, and permanent stations put in where possible; one complete, and one partial shore line survey were made; ranges were established at all points of interest, and sounded at intervals. A system of levels was established in both banks over the entire length of the reach, and the slopes taken. The alignment of the channel was also taken.

On the 20th of November, while acting under orders to proceed to Lexington, Mo., the steamer Electra was forced by floating ice to go to the bank on Harrison's Island, and was there frozen in; an ice crib was built up in front of her, and before the ice broke up, February 8, an extra crew was put on her; notwithstanding this, she broke her moorings and went adrift February 8, with no one aboard. She floated safely to Boonville, and was there boarded and landed. As quickly as possible she was repaired

*Not printed.

and sent to Saint Charles; from there she was sent to Glasgow, where she is now on duty. The details of her loss and rescue were fully given in my report to you, dated February 19, 1881.

PART II.

April 25, 1881, I submitted a project for the expenditure of the money available at that date. This project was approved and operations commenced at once for its execution. In both the revetment and the dike work proposed, the use of a wire net is contemplated. A machine for its manufacture, designed by my assistant, Mr. A. J. Frith, was constructed, and after some modifications finally adopted. This machine is described in the notes on illustrations.

The first work contemplated the construction of revetment in Cambridge Bend. For this purpose the old mattress boat, used last season, was dismantled and provided with a new set of ways for launching a low-water mat 82½ feet wide.

The ways are supported on bents 5 feet apart, and, starting flush with the gunwale, rise 3 feet in 21 feet. This slope is floored over within 2½ inches of the surface of the ways by 8-inch plank running with the ways, and spaced 2½ inches apart, to allow for the passage of a twisting tool. A light intermediate way is supported by this floor; a 10-inch continuous balloon roller runs along the gunwale at the foot of the ways to relieve the friction in paying off the mat.

An outrigger 12½ feet long projects from the shore end of the boat out over the bank.

On the outer or stream end of the boat a set of rollers are let into the ways, and on these the anchorage contained in the hem of the net is carried; along the down-stream gunwale is a row of posts 5 feet apart and 4 feet 6 inches high, in the tops of which is set a continuous roller on which the bundles of brush rest as they are passed on to the ways. A trailing boom attached to the up-stream gunwale, capable of motion in a vertical plane, but braced against motion in any other, was designed to guide the anchorage or outer edge of the mat to place.

Running along flush with the top ends of the ways are 2 by 6 inch timbers spaced 1 inch apart; to these the net machines are clamped, and may be adjusted to any required length of mesh.

The boat was ready for work on the 15th of June, but owing to delay in getting a suitable tow-boat, work was not commenced on the mattress until June 29.

In the mean time, since the date of my project, a radical change had occurred in Cambridge Bend, viz, the shore had receded some distance back of the proposed line of revetment, when, owing to a change of the right bank above, the channel moved rapidly out of the upper end of the bend, closely followed by a large reef, which almost entirely cut off the draught of water.

On the 29th of June the current infringed on the bank at a point 1,200 feet above. It was here that we started the revetment. Its construction is described as follows, viz: A netting the length of the ways is woven from the machine, the meshes of the net being 5 feet by 2½ feet, the 5 feet across the ways; on this a single thickness of 20 feet willow brush is laid, butts up stream. Five wires spaced 5 feet apart are then carried across the brush and pin-twisted to the net. About three-quarters cubic yard of rock is distributed along, near the outer edge of the mat, which is then brought up over it, and twisted down. Another fleet of netting is made from the machines, and then they are ready to launch the first fleet. The inner edge of the net is thrown over stakes along the top of the bank. From the water line to the edge, the meshes of the net are left open so that the bank may be graded. The wire used is No. 12 steel A. G. Sufficient work has not yet been done to state at what rate revetment of this kind can be made.

The machines will produce the net at the rate of 20 feet linear per four minutes, or with meshes 2½ by 5 feet; nineteen machines worked by a force of nineteen men will produce it at the rate of 270,000 square feet per day of ten hours. It is thought that this form of revetment may be improved in some respects that will economize labor.

A derrick-boat has been fitted up for use in the construction of tripod dikes. A decked flat 60 by 16 feet has been provided with a set of movable ways, and will be used in making netting for the dikes. A tool-house and coal-shed have been erected. A large portion of the material for the dikes, viz, poles and rock, has been gotten out. A number of partial shore-line surveys have been made, and the high-water slopes taken.

The present alignments of shores and channel are most favorable, especially from the Middle Bend down; they conform very closely to those proposed for the improved river.

A project with estimates for the completion of the improvements was submitted 28th ultimo.

In conclusion I wish to acknowledge the services rendered by Assistants F. W. Tuttle and A. J. Frith.

I am, Major, with great respect, your obedient servant,

S. WATERS FOX,
Assistant.

S 5.

IMPROVEMENT OF MISSOURI RIVER AT LEXINGTON, MISSOURI.

Work was begun at this point last summer, Assistant E. C. Shankland being in charge. Five thousand feet of revetment was put in on the left bank, above Lexington, during the fall, the object being to prevent further movement of the bend down stream.

This work was specially interesting, owing to its extreme lightness and cheapness, while the position in which it was placed was calculated to give the system a very thorough test.

Unfortunately, the early setting in of winter rendered it impossible to grade the bank above it, and in this incomplete state it was obliged to receive the shock of heavy masses of ice and of three successive floods. The revetment apparently received no damage, and remained in place, though the bank above it was cut so far back by the ice that during the third and greatest flood, when the whole country was under water, the river cut in behind it and the work settled in mass to the bed of the river, where it still remains.

It will be renewed this season and properly completed, the balance of funds available being used for dike work in the spring of 1882.

The estimate for this work has been revised and extended.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$15,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$25,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		10,616 30
July 1, 1881, amount available		14,383 70
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

REPORT OF MR. E. C. SHANKLAND, ASSISTANT ENGINEER.

LEXINGTON, MO., *July* 15, 1881.

MAJOR: By your letter dated July 30, 1880, I was placed in charge of the work of improving the Missouri River, at Lexington, Mo.

I arrived in Lexington August 2, and, having organized a small party, made a survey of the river from Wellington down below Lexington, a distance of between 7 and 8 miles, to ascertain what changes had taken place in this reach since the survey made in October, 1878, by Capt. D. W. Wellman, assistant engineer.

The bank in the bend opposite Lexington was found to have cut away between 250 and 300 feet. This bank has been constantly receding, and the bend traveling down stream for many years past. I am told that in 1850 the steamboat landing was at Rock Bridge, over a mile above the present landing.

The cutting has kept forcing the channel over to the left bank, and caused it to strike the right bank further and further down stream, so that at the time the survey was made last August a sand-bar extended all along the town front, throwing the steamboat landing nearly half a mile below the town, and threatening soon to destroy it altogether.

In view of this fact it was deemed best to first stop the cutting of the bank opposite the town by means of a revetment and afterwards by means of dikes, push the river

into the left bank, above Willow Creek, and bring it down parallel to the revetted bank, instead of striking it at right angles, as at present.

This plan meeting with your approval, a mattress boat and two barges were built and the revetment commenced about the 1st of October.

As the bank is a perpendicular one from 15 to 20 feet high, and covered with heavy timber out to the edge, it was decided to put in at first, only the low-water revetment 70 feet wide, and afterwards grade and revet the upper bank, when the hydraulic grading apparatus, then in use elsewhere, could be obtained. It was determined to use a wire net, as the basis of the mattress, and weave brush into it, as suggested by Assistant L. E. Cooley in his report for 1879–'80.

Accordingly a platform 18 feet wide and 70 feet long was laid upon the bank. In this platform holes were bored in rows, 1 foot apart, the holes being every 2 feet in the rows, and 50 spikes were put in the holes. A man with a hand reel of wire goes along up and down the rows, uncoiling the wire as he goes, and a man following him puts the wire over the spikes. Four men follow them, and pulling out the spikes, give the wire three complete twists, and drop the spikes on the platform.

When the eleven rows are filled, the net is pulled over, the spikes replaced, and the operation repeated. When the net 18 by 70 feet was completed, it was rolled on a cylinder 18 feet long, which as soon as three nets were rolled on it, was carried to the boat, and unrolled on a platform across the boat, and connected by twisting with the net already in the water, so as to make a continuous mat.

Brush was then woven in and out of the meshes, making a thin but strong mat. It was weighted with rock, but allowed to float in the water, for about 200 feet behind the boat, in order to catch all the sediment it could before sinking.

The greatest day's work was 550 running feet, or 385 squares (a square being 100 square feet), with twenty-eight men, this number including foreman, brush weavers, and wire net makers; 372 running feet, or 260 squares of wire net were made in five hours, with 17 men, or at the rate of nearly 75 feet, 52½ squares an hour, at a cost of 9.8 cents per square, or including cost of wire 25.6 cents per square; 5,100 feet, 3,570 squares, were put in at cost, including cost of wire, of 52 cents per foot or 73 cents per square.

The work was frequently delayed on account of the wire not being delivered on time. It is believed that thirty men can make the net, weave in the brush, and sink 900 feet, or 630 squares, per day.

The low-water revetment was completed November 3. It was intended to commence the upper bank protection immediately, and the grading plant was ordered by you from Glasgow to Lexington, but the sudden coming on of cold weather filled the river with ice, and compelled the boat to return to Glasgow to winter.

The excedingly high-water this spring prevented anything being done at bank grading until June 13, and it is now in progress.

Cross-sections taken two weeks apart in October and November showed a deposit of from 8 to 12 feet of silt over the mat, and in November there was 15 feet of water at foot of Pine street, where there had been but 2 feet when the work was commenced.

The revetted bank was entirely covered during the high-water in April, and it cut about 350 feet at the point.

Soundings were carefully made in May, as soon as the river had fallen sufficiently, and the mat was found in place, but scoured bare over almost its entire surface, and in some places lowered from 5 to 10 feet, the water having scoured under and let the the mat down.

Preparations were made in June to put in three screen dikes at Goodwin's coal banks, 3 miles above Lexington, to force the river out of the bend at the coal banks, and across the river into the left bank, just above Willow Creek. The dikes, however, were not commenced until the present month.

* * * * * * *

I desire to acknowledge the valuable services of B. V. Simpson, assistant on the work, and John Sweeney, foreman on construction.

I am, major, very respectfully, your obedient servant,

E. C. SHANKLAND.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 6.

IMPROVEMENT OF MISSOURI RIVER AT KANSAS CITY, MISSOURI.

It had been in contemplation to begin work at this point during the spring, but this was rendered impossible, for reasons already alluded to.

The damage done by the floods in this neighborhood was very great. The revetment put in in 1879 received but little damage, and undoubtedly prevented the formation of a cut-off, which would have isolated Kansas City from the river. All other work done at this point was swept away.

As soon as possible revetment work will be undertaken, the old work being repaired and extended. When a favorable time occurs dike work will be begun, and pushed as far as practicable.

So many changes have occurred that a revision and extension of the estimate has been found necessary.

The work has been in charge of Assistant John W. Nier.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$25,156 96	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$45,156 96
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1,1880		21,244 35
July 1, 1881, amount available		23,912 61
Amount (estimated) required for completion of existing project		220,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

REPORT OF MR. J. W. NIER, ASSISTANT ENGINEER.

KANSAS CITY, MO., *July* 22, 1881.

MAJOR: I have the honor of submitting the following report of the progress of the work of improving the Missouri River at and near Kansas City, for the fiscal year ending June 30, 1881.

The past year has been occupied in the preparation of plant and in surveys, the active work of improvement having been interfered with by a chain of circumstances wholly beyond my control.

The work of 1879 has given excellent satisfaction, and considering the fact that it is in an exposed locality, subject to a radical change from above, its success is most gratifying. The impossibility of locating a short revetment to successfully withstand the full force of the current, caused by shifting of the channel, and the dire necessity of commencing at the head of the reach, at some nodal point, and continuing the work down stream in an unbroken line, are amply proven on this reach.

The trend of the bend below Quindaro has caused a very marked shifting of the axis of the stream on Line Creek Crossing, the point of impact of the stream having traveled up stream 4,000 feet, resulting in cutting a pocket about 600 feet deep, just above the revetment, and a turning of the stream around the head of the revetment. Had the first appropriation for work at this point been adequate to the needs of the case, the work could have been extended up stream several thousand feet, and fully guarded against the changes which have taken place.

The upper end of the revetment successfully withstood the action of the current until the disastrous flood of April, 1881, when about 200 feet of it gave way.

The development of the pocket above the revetment so altered the stream that the river rushed against the lower 3,000 feet, resulting in washing down the upper bank protection and in a general dislocation of the work, but not in its entire destruction.

This portion of the work was also exposed to wave action caused by prevailing heavy southwest winds. The open character of the revetment allowed the free action of the water through it, which resulted in the caving of the bank and the falling of the upper bank work. The thorough protection of the upper bank is of the greatest necessity, and judging from past experience it seems that no construction of brush is adequate to the wants of the case. Rock placed upon the bank sloped to a grade of 3 or 3½ to 1, with willows cultivated on the upper portions of the grade, would probably be sufficiently strong.

The weed dike built in 1879 has been destroyed and the good results given by it entirely lost. This is a source of great regret, as its failure has somewhat complicated the problem of removing the channel from Lower Kaw River Bend.

The defects of tree weeds, as shown upon this work, forbid their use again.

On the whole the work of 1879 has been of great benefit, and the damage it has received can be solely attributed to the lack of funds to prosecute the work to the extent that was essential and at the proper time.

Funds not being available, nothing but preparation of plant with a view to resuming work in November, 1880, was attempted.

The sudden and early freezing up of the river at that time necessitated the postponement of operations until spring, 1881. During the winter, plans were matured by a Board created for that purpose for the construction of two grading boats and their building was assigned to me. Active operations were commenced on them March 30, and they were completed July 10.

The terrible flood of April of this year, during which the water at this point reached a height of 27.5 feet above the zero of the Kansas City gauge, effectually forestalled anything in the way of improvement. During the height of the flood every available boat at my command was used in saving life and property.

The launch Sabrina with barges in tow passed through the streets of Harlem removing people and property to a place of safety. Without the aid given by boats belonging to the improvement work, the loss of property would have been very great. The report would be incomplete were I not to call attention to one fact that in its main features has an important bearing on the levee system along the Missouri and Mississippi rivers.

During the rise of the water the current was very violent, and in consequence thereof the banks caved very rapidly.

Heavy scour of the bottom and enlargement of the stream bed were noticeable until such time as the river got over its banks. Above the village of Harlem a levee several hundred feet long and about 4 feet high was constructed by the citizens and railway companies to prevent an overflow of Harlem Flats. But this levee broke, and a general inundation of the entire bottom north of Kansas City Bridge ensued.

The effect on the velocity of the current in the main channel, which up to this time was very rapid, was immediately noticeable in its being materially slackened.

The natural inference would be that owing to the great increase of section due to overflow, the rate of rise of the water, as shown by the gauge, would be much less than when the river was between its banks. This was not the case, however, as the river continued to rise very rapidly until the entire bottom from bluff to bluff was inundated. From this I am led to believe that the levee system is absolutely essential when the natural heights of the banks are not sufficient to keep the river in bounds. So long as the river is between its banks it will scour out its bed to accommodate the water passing through it, the scour of the bottom being about equal in cross-section to the increase of section due to the rise of the upper surface. This will obviously be the case so long as there is no overflow. During overflow the cross-currents caused by the current in the direction of the axis of stream interfere with those in the direction of the stream bed in such a way that deposition of material must take place in the stream bed, correspondingly lessening its sectional area. This may fully account for the rapid rise of the water on the gauge after the discharge section had been multiplied several times by the general overflow in the direction of the axis of the valley.

It would seem, therefore, from the reasons given, that floods are a benefit to the river rather than a detriment so long as an overflow does not occur and when the banks are prevented from cutting by being well protected. The natural result of protection work would be to lower the bed of the stream and in time to give such a height to the banks as to afterwards avoid overflows. A levee system, therefore, seems necessary at first, but by the agency of works for permanent rectification would in time be useless.

A review of the situation at Kansas City seems to show the necessity of rebuilding the levee destroyed by the April flood.

The banks about a mile north of the Kansas City Bridge were lowered 2 or 3 feet; and had the flood continued several days longer, it must have cut a channel back of Harlem, and isolated the bridge from the river.

The situation at present is by no means encouraging. Deep pot-holes are found all over the area first overflowed, many of them being small lakes. The amount of sediment deposited during the flood was surprising, as away from the direct course which the overflow took across the neck back of Harlem, and especially where there was any protection, such as woods or houses, the surface of the ground was raised from 2 to 6 feet. Had dikes been constructed before the flood some great results might have been expected.

The high prices of material and labor are sources of serious embarrassment, and with

the small appropriations available at this place preclude the possibility of planting any except small work, which is entirely inadequate to overcome the difficulties presented.

Respectfully submitted.

J. W. NIER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 7.

IMPROVEMENT OF MISSOURI RIVER AT FORT LEAVENWORTH, KANSAS.

Some repairs to the old work were found necessary and were executed during the fall. During the spring and summer floods great damage was done to all the work, and the older portions put in in 1878 were totally destroyed. The funds available are entirely inadequate to replace this work; the more important portions only can be repaired at present, and efforts will be made in the spring to divert the current from the bend where it has done so much damage. A revised estimate is submitted herewith.

The work has been in charge of Assistant G. T. Nelles.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$8,451 35	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$16,451 35
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,171 78
July 1, 1881, amount available		11,279 57
Amount (estimated) required for completion of existing project		90,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

REPORT OF MR. G. T. NELLES, ASSISTANT ENGINEER.

LEAVENWORTH, KANS., *July* 15, 1881.

MAJOR: I have the honor to submit the following report on the work of improving the Missouri River at Leavenworth, Kans., for the fiscal year ending June 30, 1881.

The field operations during the year have been quite limited, no new work having been inaugurated until late in June, 1881. It was the intention to begin work earlier, so as to take advantage of the April and June rises. The extreme high-water during the latter part of April, by shutting off all rail communication, made the completion of the plant an impossibility, materials for this purpose not being obtainable.

The June rise of 1880 did considerable damage to the work, leaving the shore line very irregular and full of holes and deep pockets. I quote from a report on the condition of the work, dated August 11, 1880, the following:

"The mats in many places have either gone out entirely or slipped so far as to be practically useless. The water is not particularly deep along the bank or over the work, but a depth of from 35 to 45 feet exists throughout the reach at a distance of 150 to 200 feet from shore. * * * "In sounding at some distance from the shore, the lead frequently fouled, showing that the mats had not gone entirely out of the bend, and that they were much broken up." These breaks, although similar in appearance, differ in extent from those which occurred on this same part of the work during the rise and all of the river in June and July, 1879. Last year the mats were always found in position; no perceptible slipping was ever noticed; this year more or less slipping was noticed in every case."

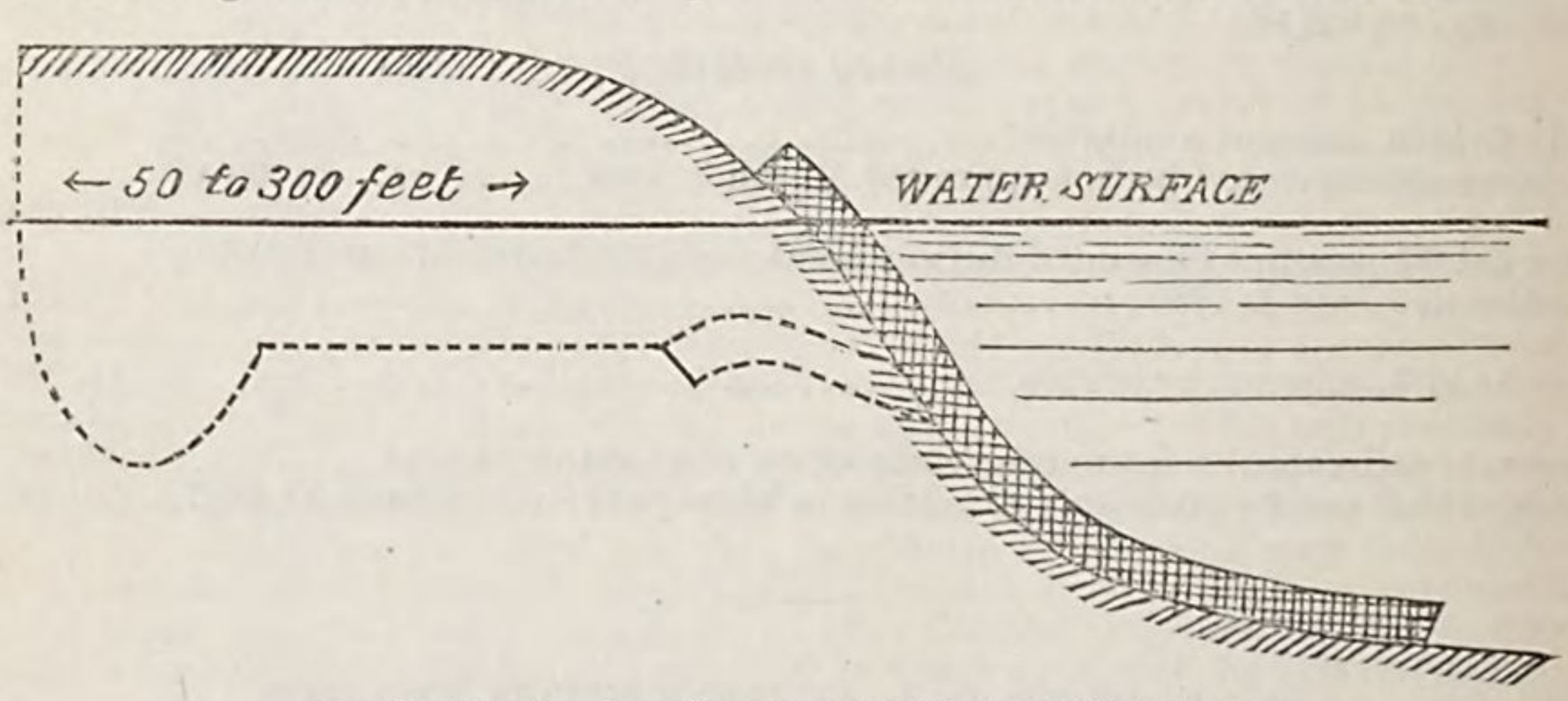
This slipping was undoubtedly caused by a deeper scour outside of the work as indicated by the soundings and by a weaker condition of the work, due to a year's exposure, offering less resistance to parting.

These breaks occurred in the work put in by Assistant Engineer D.W. Church during the fall and winter of 1878 and the spring of 1879. The work consisted of detached mats and independent high-bank protection, staked and wired together at the junction. The mats were from 60 to 75 feet wide and from 10 to 14 inches thick, made on pole frames, as strong and at the same time as flexible as possible; a large quantity of stone was used in sinking and placing. It had been previously severely tested and was thought particularly strong, especially the 75-foot mats.

Repairs were made during September and October, 1880, by building mats on temporary elevated ways, of sufficient size to fill the gaps and lap well onto the old work. Brush was laid one way to a thickness of 10 inches, on a frame of light cotton wood or sycamore poles, and then sewed directly to the poles, no binder except the wire being used on the top. The high-bank protection was made by laying brush parallel to the river, on brush fascines securely wired to the low-water work, laid 6 feet apart and extended up the bank to high-water mark. The brush was sewed to the fascines with circular needles with stitches 3 feet long. The cost of this work was $987.60, including stores.

After making these repairs, no further injury was done to the work until previous to the April rise, 1881. The extensive cutting above the work from above Bee Creek to the root threatened to take out the work by cutting in behind it. The root having become rotten and weak from exposure, work was commenced to strengthen it and arrest the threatened danger. However, before much could be done, the first flood came, overflowing the banks and carrying away brush and other material on hand. The continuance of this work without a more extensive plant was thus made impossible. Before the bottom roads became dry enough to haul material to complete repairs, the second and greatest flood came.

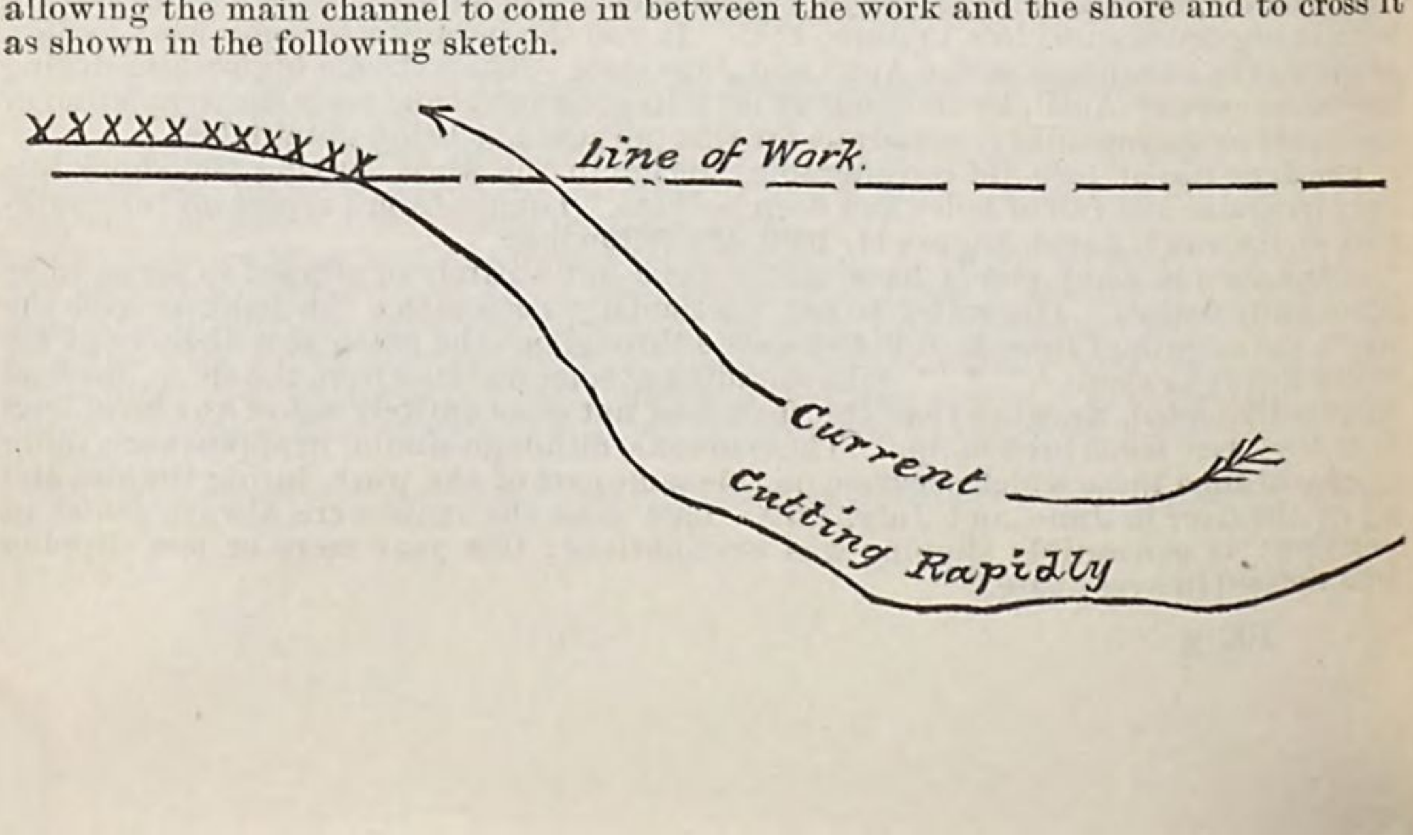
During this overflow the bank cut in behind the root from above, taking out, or at least rendering useless as a means of protection, about 500 feet of the work.



Depth at inside edge of work, 0 to 12 feet at 10-foot stage.

The above sketch shows the original and present position of the bank and work.

The work remained along its former line until about June 15, forming a reef over which the current ran. The bank cut in about 300 feet behind its former position, allowing the main channel to come in between the work and the shore and to cross it as shown in the following sketch.



The erosion throughout the unprotected portion of the bend has been very severe. The cut at Bee Creek Point, which was formerly much slower, has been more rapid than at any other point in the bend. The uniform curve so earnestly desired under former projects has been attained and will soon he passed. A map which will follow this report shows clearly the changes which have taken place in this bend since work was commenced in 1878.

The strength developed by the "upper mattress work" put in by Assistant Engineer D. W. Church during the winters of 1878 and 1879 has been a matter of wonder to all who have had an opportunity to inspect it. The strains brought to bear on it by the two floods of April and May it withstood with no damage, and it was only by the cutting out from behind that its usefulness was impaired. If it was thought essential or necessary to hold this work, it could be done even now, and be made fully as efficient, if not more so, than ever before, provided, of course, steps be taken at once to prevent further washing out from above.

In May surveys were made, extending from Weston to Leavenworth, to determine the best location for a dike to throw the river entirely out of the bend and into its former channel along the Kansas shore. The results of this survey and the consequent location of the dike are shown on accompanying tracing. The soundings show a uniform section at number 5 and a divided one at number 6, indicating a natural tendency of the river in the desired direction, beginning at a point somewhere between these sections. After consultation with you, and fully considering the merits and demerits of all possible locations, the one marked in tracing was decided upon as offering the best chance of success with the greatest ease of construction.

This question being settled, operations were commenced late in June on the construction of this dike. A single row of piles from 15 to 20 feet apart is to be driven, extending out between 2,000 and 3,000 feet, as may be found necessary, and a wire netting is to be suspended up stream from a cable made fast to the heads of the piles. The mesh used at first will be triangular, 30 by 15 inches. Such changes will be made in size and shape of mesh as experience dictates.

So little actual work has been done on the dike that no estimate of cost or suggestions concerning it can be made at present. A description of the pile-sinker apparatus and the net machine used will be given in the annual report for improving the Missouri River at Atchison, Kans.

The plant being used belongs conjointly to Atchison and part to Saint Joseph. The cost being thus divided up, a very considerable saving is effected, making it possible to do better and more substantial work than otherwise could be done with a small appropriation. The great disadvantage of this system is that work of the same nature cannot be done at but one place at a time, whereas it may be frequently necessary to take advantage of the same rise or condition of the river at each of the places interested which may endanger the local interests.

Great damage was done to the farms in the bottoms by the spring floods. The only permanent change in this reach due to it was the cutting off of Satan Bend, the river taking what is commonly known as Cow Island Chute. No surveys of the locality have been made. A personal examination of the chute showed that the main body of the river flowed through it; a channel depth of 20 to 25 feet exists throughout its length.

No very marked channel exists in the bend, and care must be exercised in running through it with a steamer.

Assistant W. E. Dauchy has been in local charge at this point.

A bench mark, 1.43 feet above extreme high-water, was set on top of stone foundation of northeast corner of Union Depot at Leavenworth, Kans. This bench reads 27.53 feet, Signal Service gauge.

I am, major, very respectfully, your obedient servant,

G. T. NELLES,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 8.

IMPROVEMENT OF MISSOURI RIVER AT ATCHISON, KANSAS.

No work beyond that of preparation was done here during the past season, the operations contemplated this spring having been prevented by the floods.

The old works have stood fairly well, but will require considerable extension to make them safe. This and other work contemplated will be undertaken as soon as possible.

So many changes have occurred in this vicinity that a revision of the estimates has been found necessary.

The work has been in charge of Assistants E. H. Wilson and G. T. Nelles.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$20,004 42	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$40,004 42
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		17,007 28
July 1, 1881, amount available		22,997 14
Amount (estimated) required for completion of existing project		125,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		60,000 00

REPORT OF MR. G. T. NELLES, ASSISTANT ENGINEER.

ATCHISON, KANS., *July* 22, 1881.

MAJOR: I have the honor to submit report for the fiscal year ending June 30, 1881—improvement of the Missouri River at Atchison, Kans.

Previous to my appointment to the local charge of this work, a complete survey of the reach extending from Geary City to the Atchison Bridge was made by Assistant Engineer E. H. Wilson.

A map of this survey scale 2,000 feet equal 1 inch, also showing the shore lines of other surveys, will accompany this report.

No works of improvement have been constructed during the year. The only work done, except surveys, has been the construction of a plant for future operations. This plant consisted of a pile-sinker apparatus for use at Leavenworth, Atchison, and Saint Joseph, and was paid for proportionally by them; a barge 65 by 12 feet for Atchison; a barge 75 by 12 feet for Leavenworth; an arrangement for making continuous wire netting of any width up to 75 feet, placed on the large mattress boat used here in 1879; and the repairs and alterations of the two small barges belonging to Atchison. Tracings of these constructions will be sent with this report.

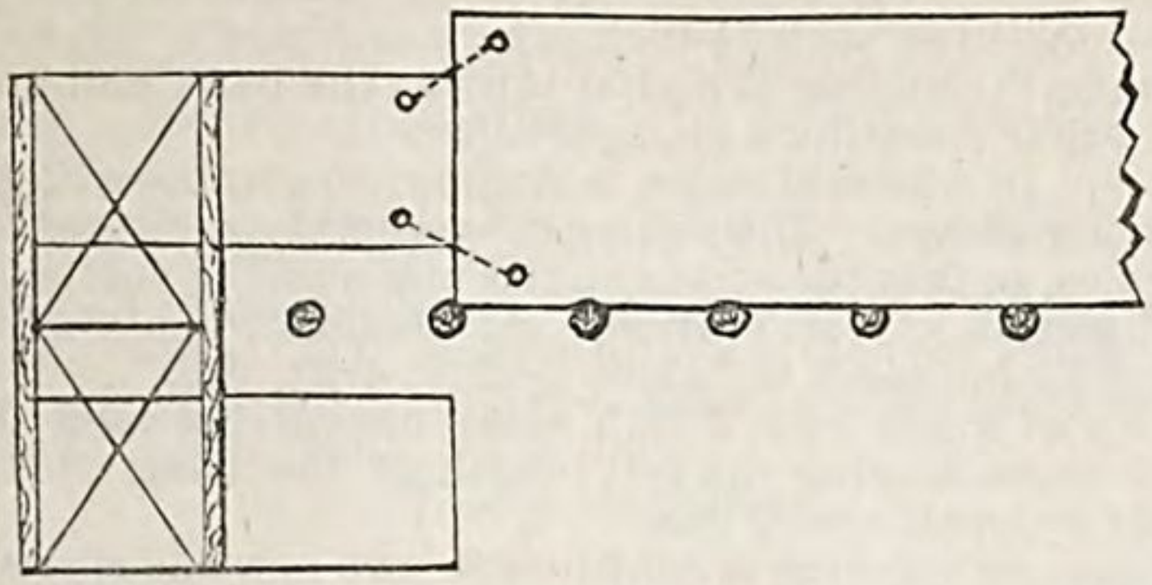
On the receipt of your letter of March 9, 1881, and the accompanying report and drawings of the "Pile-sinking Board," arrangements were made for the construction of this apparatus as directed. In accordance with your suggestions, efforts were made to cheapen and simplify the designs by changing the details without altering the general design of the Board.

The forked or "turn-table" boat is 26 feet wide and 30 feet long, with a well 6 feet wide and 20 feet long. A truss extending 8 feet above deck is placed at the open end to stiffen this boat. The guides or leads are secured to the turn-table, so they move with it. The turn-table moves on rollers in the deck, the center being at the center of the well. The leads are adjustable to any angle, and can be placed in any position by means of the turn-table and extension-props at the bottom and top.

The arrangement adopted will not admit of rapid changes of inclination, but as this will hardly ever be necessary, it is deemed sufficient. The leads are made to take a 38-foot pile. Shorter ones can be readily handled, and longer ones to almost any length with more trouble, in proportion to the increased length. The arrangement and leading of the lines and the pile-carriage have not been satisfactorily perfected. Five clutches to prevent overturning and to hold the turn-table in any desired position are placed at intervals around the table. A line is led to the winch for turning the table.

The machinery is all placed in a barge 60 feet long and 16 feet wide, with 45° side rake, and a square end to butt against the square end of the turn-table boat. This boat can be made fast to either fork of the turn-table boat by means of large iron hook-couplings or chains with open links. It being 6 feet wider than the fork, an easy and

secure fastening can be made. It can also be placed so that its side will bear directly against the piles already sunk and at the same time bring the center of the leads on ro the line.



For the turn-table boat the smaller barge in the catamaran mattress-boat, built by Assistant Engineer D. W. Church, was cut in two and the pieces strongly framed together by means of a heavy Howe truss in the solid part of the bow, making an almost rigid connection. As before stated, a vertical truss was placed at the open end. An entirely new boat was built for the machinery.

Notwithstanding that a steam-dome and a heater (neither recommended by the Board) are used, the boilers with ordinary coal will not make sufficient steam to run both the pump and the winch at full force. As they are always needed at once, this is a most serious fault, which should be remedied as far as possible. With careful watching and firing, 60 pounds can be held. This gives about 50 strokes per minute of the pump.

The steam-windlass is not suited for the use it is put to; it is not sufficiently powerful. We frequently stopped it on an ordinary pull. Under heavy pressure the casing in which the piston-rod works is pressed in from the bearing and allows an escape of steam. It frequently stops on the center and must be started again by hand. Both drums turn in the same direction, being run by the same steam-cylinder, so that but one drum can be used advantageously at a time. A much better economy of time in working the pile-sinker could be obtained with a winch with independent drums. An air-chamber should be put on the pump to prevent pounding and the consequent wearing of the valves and straining of the machinery.

One-inch lines were used at first, but frequent breakages led to the substitution of $1\frac{1}{4}$ and $1\frac{1}{2}$ inch.

But few piles having been sunk to the end of the fiscal year, only a limited opportunity was obtained for studying its workings. Means for placing the pile in the leads and attaching the pipe must be devised, so that no time will be lost.

The sinking and work after the pile was ready to sink never took over five minutes. The placing in the leads, either by a pull directly from the top of the leads or by means of a derrick, was a source of constant loss of time.

The theory of always having a pile in the derrick to lay in the guides is a good one, but until a double winch is obtained, it cannot be fully tested practically. There is no doubt that when everything is fixed for it, a better economy of time will be obtained with the derrick than by any other means. A carriage must be provided, to which the pile can be firmly attached by one motion.

The arrangement used was far from perfect. No running of the pile, due to the pressure of the current on it, was noticed. After getting fairly started, the line of the dike was easily kept.

The precautions taken by the Board to guard against overtopping of the leads by the pressure of the water against a pile were to a certain extent unnecessary.

In the 18 feet of water with a strong current and against a cutting bank no trouble was experienced in holding or moving the pile with a short beam when nearly to the bottom. After the pile rests on the bottom it stays where put.



It is thought that not more than 40 piles a day can be sunk under the most favorable circumstances with this apparatus, as it now stands.

The piles sunk were all slightly sharpened and peeled for the first 10 or 12 feet, the hydraulic pipe being introduced at the center of the bottom.

The following experiment led to the adoption of this method of preparing them. Two piles were sunk close together through about 4 feet of clay. The first one was blunt, and had the bark on; the other was prepared as above. The greatest difficulty was experienced in getting down the first one; the lines and machinery were severely strained in the attempt. The second one, after a slight stick at first, went down easily. In pure sand the piles frequently sank by their own weight 8 or 10 feet. In sand there seems to be no limit of depth to which a pile can be sunk.

We succéeded in sinking one 28 feet, and then stopped on account of pile giving out. No twisting or shaking was found necessary to sink the piles.

Experiments were tried with different-sized pipe and hose, 1 to 2 inch pipe and 2 to 2½ inch hose; 2½-inch hose with 1½-inch pipe was found to give the best results.

The tests were made by holding the pipe against the bank and noting the time and size of hole cut, all other conditions being similar.

It is thought, except in unusual cases, a single row of piles will be sufficient for a net put in at the proper season. The net must be securely anchored to prevent slipping down against the piles, so that the strain on the pile shall be vertical, or nearly so, and not a push in the direction of the current. At seasons when there is little sediment in motion, extra precaution must be taken against drift, &c.

The 65-foot barge was made with 2-inch sides, braced between the frames by four rows of 2 by 4 inch cross-bracing the full length of the boat. Notwithstanding this precaution, the ends dropped out of line.

A pin-twist machine for weaving a continuous wire net was rigged on a barge 75 by 12 feet. By changing the pin boards any size of mesh can be made.

One of the old barges was made into a coal-barge for the steamer and pile-sinker; the other one was made into an office and tool boat.

Since the steamer Melusina reported to me in April at Kansas City, several changes and additions have been made on her, suggested by convenience or necessity. Bulkheads have been put in forward and aft of the boiler, separating the boiler-room from the coal and leaving a comfortable cabin for the crew. The cylinders have been lagged and the steamer painted throughout. A slight increase in the bucket-width showed such a decided improvement in handling that further increase will be made.

No very extensive damage to life or property occurred in this vicinity during the spring floods. The bottoms were for a time abandoned and the crops for the season ruined.

The greatest and almost only change of importance on the reach due to the high-water was the shifting of the main channel from Rushville Bend to Indian Chute. This change will cause a cut on the point opposite Doniphan, and probably in the bend below.

During the higher stages the river took a straight course across McQueen's Bend, and no further deepening of the bend took place. The crossing out of McQueen's Bend in low-water is so direct that a partial return is effected before passing the bridge, the deepest water being at the center of the bridge, instead of under the draw-span. In November, 1880, a bar was formed under the draw-span which at a 4-foot stage appeared above the surface. One up-bound steamer was held for two days, and one down for several hours, by this bar. The bar scoured out later, and has not made its appearance since.

Cross-sections immediately above the bridge, at different stages, will accompany this report.

For the first time since 1878 a cut has taken place this spring along the Missouri bank above the bridge. This has not been at all extensive, still it has been sufficient to alarm the residents and bridge people.

A tendency on the part of the river to take the chute behind Atchison Island is apparent at the higher stages of the river.

Immense quantities of drift and water take this course. Should McQueen's Bend cut much deeper, this tendency will be favored by the increased channel-length by way of the bend. This should be watched and prevented.

I was assisted in the construction of the plant by Mr. D. W. Kinnard, who for a short time was in local charge of this work.

Very respectfully, your obedient servant,

G. T. NELLES,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 9.

IMPROVEMENT OF THE MISSOURI RIVER OPPOSITE SAINT JOSEPH, MISSOURI.

Operations during the past season at this point have been confined to repairs of old work, the projected spring operations having miscarried here as at other points. Some damage was done by the ice and floods,

principally by destroying the old dikes at a time when the bank behind them could not be secured. Their removal had been contemplated, but not in such a summary manner. These damages will be made good during the present season, and the revetment in Bonton Bend will be put in. In the coming spring dike-work will be undertaken. The estimates for this work have been revised and extended.

Assistant D. W. Church has been in charge of the work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$21,155 61	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$41,155 61
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		13,232 34
July 1, 1881, amount available		27,923 27
Amount (estimated) required for completion of existing project		223,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		90,000 00

REPORT OF MR. D. W. CHURCH, ASSISTANT ENGINEER.

SAINT JOSEPH, MO,, *July* 18, 1881.

MAJOR: I have the honor to submit the following report on the work of improving the Missouri River at Saint Joseph, Mo., during the fiscal year ending June 30, 1881.

In the annual reports on the work at this point for the past two years, mention has been made of the probability that a new channel would be formed at Amazonia, Mo., by the river cutting through the neck of land opposite that point.

The expected cut-off was effected July 22, 1880, by continued erosion of the down-stream side of the neck. At the up-stream side there existed a narrow, deep bed of clay, which so resisted erosion that during the 24 hours previous to cutting off the width of the neck was only 8 feet, and although there was a difference of elevation of the water's surface above and below of 2.78 feet, this bank was entirely removed by ordinary cutting before the water began flowing through.

The first effect immediately above the neck was a lowering of the water's surface 2.7 feet within 40 minutes after the opening was made. Several bars lying above the neck, and separating it from the main channel, were rapidly removed, and a quickly-changing channel was formed leading the river to the opening.

The distance around the point by channel was 4½ miles. The current flowing around was checked at once, and ceased entirely in a few days. The Nodaway Chute leaves the Missouri near Nodaway, and enters the old channel near Amazonia, which it follows to its meeting with the present channel at the cut-off.

This chute served to keep a slight current in a portion of the deserted bed, and to prevent its entire filling up at the lower end. At the upper end the filling was rapid, and within one month a dry bar was formed from shore to shore. Below the cut-off, for a distance of about 4½ miles, there were extensive changes during the entire season, the river first cutting into one bank and then into the other, replacing each time the material previously taken out. No effects of this nature were traceable below Bonton.

A short time before the cut-off was made, a temporary gauge was established at the narrowest part of the neck, another about 5 miles up stream, and a third at Amazonia.

It was intended to notify the observers at these points and at the regular gauges below when the cut-off took place, and have readings made every half-hour, but as this occurred about 8 o'clock in the evening, the observers could not be notified, and, with the exception of those made at the cut-off, the night readings were lost. Readings taken next day showed nothing which could be traced to the cut-off.

In October and November, 1880, a survey was made from Saint Joseph to Charleston, Kans., a distance of about 30 miles; the shore lines were run up stream, and the soundings and slope measurements made on the return. A slope reading was taken at every alternate sounding section (about every 2,000 feet), both at the shore and in the channel, the latter reading being taken on a floating-rod so graduated as to be easily read at a distance of 1,000 feet, and supported vertically on a plank platform 8 feet

wide by 12 feet long. A stadia-rod was also carried on the platform. In observing, a level and transit were placed near a bench on the sounding section, and the elevation of the water taken at shore with the ordinary level-rod. The float was then allowed to pass, and as it crossed the section the distance was read on the stadia-rod by the transit, and the elevation by the level. This work could be done nearly as fast as ordinary slope measurements, and no difficulty was experienced in making accurate readings.

The slope and cross-section work had only proceeded about 10 miles down stream when ice began running, and three days after the river closed. This occurred November 17, much earlier than was expected. Several high-water chutes and old bank lines were then run, and the leveling continued until the weather became too cold to work advantageously. During the winter the survey notes were platted, numerous old bank lines were run, and the leveling continued when the weather was suitable. Information was also collected from old maps and other sources, relative to former locations of the river. The river remained covered with ice from November 17 until March 15, and during this time the weather was exceptionally cold. The general thickness of the ice formed was from 18 to 36 inches, but in many places, where shoal water existed, the latter thickness was exceeded, and the channel was greatly choked by the ice extending to the bottom. As a natural consequence with such a thickness of ice, great changes were produced, both during the winter and when the ice moved. The smaller channels were entirely closed during the winter, and when the break-up occurred new ones were cut wherever necessary to the direction of flow or to provide sufficient cross-section. In some places the river permanently abandoned the former channel, and followed the one cut by the ice.

The revetment above Elwood was injured at dike No. 3 by the formation of an ice gorge in November, and on the upper side of the dike a break was made, which it was impossible to repair during the winter. Very little change took place until the ice moved in the spring, when another gorge was formed at the dikes. The ice piled up on the points of the three dikes and carried away considerable of the stone-work, leaving little else but earth exposed to the current. During the period of extreme high-water, which followed the going out of the ice, the dikes were entirely cut away, and about 1,000 feet of revetment adjoining the two lower dikes were carried out. Heavy ice ran for nearly three weeks following the break-up, and prevented anything being immediately done toward replacing the revetment. As soon as the river was free from ice, work was commenced, although many difficulties, due to the height of the water, presented themselves. Willow brush could not be obtained, as the bars were submerged, and it was therefore necessary to procure upland brush. It was also necessary to construct elevated ways, as they could not be laid on the graded bank. Only one mat was placed in position and another nearly completed when the river, which was rising steadily, reached the top of the bank and stopped all work. This rise covered all the bottom lands to a depth of several feet, and remained above the banks about twelve days. On receding it left such a deposit of sediment that the bottoms were not in condition for work to begin for 8 days. Everything done previous to the rise was lost and the breaks were greatly extended, the bank continuing to cave badly as the water fell. The highland brush supply was exhausted, and as no willow could be obtained, the plan of mattress protection was abandoned. Instead it was decided to use a wire screen as a protection, suspending it first in front of the bank until the meshes were sufficiently filled with vegetable matter to form a protection, and then placing it in contact with the bank throughout. This plan was entirely experimental, but from the known action of a screen it was believed that the bank could at least be held temporarily, and as information was desired regarding the permanency of such a protection, it was thought that the experiment would prove of much value.

The net was made on a frame-work 22 feet long, 4 feet wide, and 8 feet high, with a drum 20 feet long on one side and reels for the wire on the other. A platform was placed over the reels for the men to stand on, and on the same side, at the top of the frame, were pin-boards, over which the wires passed in forming the mesh. The twist was made between the pin-boards in the manner heretofore in use on the river known as the pin-twist method, and to form a new intersection the wires changed by hand. The mesh was in form of an isosceles triangle, with an area $\frac{83}{100}$ square feet, the base of the triangle being 24 inches and the altitude 10 inches. Number 12 wires running parallel to each other formed the bases of the triangles, and number 14 the diagonals. The rest was made 20 feet wide, and in lengths of about 300 feet. The best speed attained per man per hour was 133 square feet, but the usual speed was only about half that amount, on account of the inexperience of the men.

By the time sufficient net was made to begin placing, the river had reached such a stage that there was very little cutting at dike number 3, and work was therefore begun at dike number 2. The net as placed was 72 feet wide, anchored at the outer edge with bailed rock, and supported about midway between the anchor line and shore by barrel buoys about 8 feet apart. Between the buoy line and shore, the net hung loosely in the water, and was attached by number 8 wire to posts set in the

ground; 590 linear feet of shore were covered in this manner. The shore line being in the form of a pocket, the net did not at all times receive the direct action of the current, and the accumulations of vegetable matter were probably not as rapid as they might have been in more exposed locations. The only portion of the material caught by the net which could be relied on as a filling was that composed principally of fine roots and grass, which collected about the wires slowly until a diameter of one-half or three-fourths of an inch was reached, when it either ceased to collect or was worn away by the current in proportion as it accumulated. The fiber was too short to bridge any but a very small mesh, and was devoid of the strength and lasting qualities which are necessary to resist the continued action of a strong current. A great quantity of bark and dead twigs was caught, but it was of very little service, as it was not entangled in the net, and a change in the direction of the current would have removed the greater part of it. The net was not thought to be sufficiently filled at any time to form a protection when laid on the bottom, but its action with the buoys attached was very satisfactory, as it not only prevented erosion, but threw down a deposit in the pocket through its entire length. In about one month the fill reached the surface of the water in places, and the buoys were removed, since which time there has been no change that might be taken as an indication of the net's future action. The heavy drift which ran during nearly the entire spring made the work of placing and maintaining a wire screen very difficult, and it was necessary to use great precautions to prevent the net from being destroyed. During the day a skiff crew was almost constantly employed in intercepting it, and at night the barges were so placed as to form a protecting boom.

When the above described work was completed, the cutting at points below had almost entirely ceased, and as a continuance of operations at this point would necessitate the neglecting of preparations for the regular season's work, it was decided to allow the remaining breaks, comprising a shore length of 2,400 feet, to go unrepaired for the present.

The removal of the dikes was included in the plan of operations for the season, but it was not intended that they should be removed at a time when the work could not be kept under complete control. It is believed, however, that the result will be beneficial in reducing the slope and destroying eddies.

A number of experiments were made during the month of March in joining wire together with different twists, preparatory to designing a machine for making net. As a result of these experiments it was found that the tension required in making a close twist brought great strain upon the machine; that, however smoothly the wire passed through the machine, there would be sufficient binding to require considerable force in drawing it out, after making a twist; that the elasticity of the wire would cause it to spring off if wound on a core 1 or 2 inches in diameter, and consequently broad spools of small diameter could not be advantageously used; that the wire could not be drawn out without danger of breaking, if turned at an angle approaching 90 degrees, in passing from the spools to the twist; and, finally, that a machine to be successful must be strong in all its parts to withstand the unavoidable strains, must be positive and simultaneous, and be provided with such a device that the tension would be applied only when making a twist.

A machine was constructed with the above requirements in view, the description of which will be omitted until the drawings are completed, on account of the difficulty in satisfactorily describing it without them.

Four barges were constructed of the following dimensions, viz, one, 60 by 12 by 3 feet and 2 inches over all, gunwales 5 inches thick, rake $3\frac{1}{2}$ to 1; two, 50 by 12 by 2 feet and 8 inches, gunwales 4 inches thick, rake $3\frac{1}{2}$ to 1; one, 40 by 10 by 3 feet and 4 inches, gunwales 5 inches thick, rake $1\frac{1}{2}$ to 1.

The rakes were curved at the intersection with the bottom and a longitudinal bulkhead was made in each boat. They were also provided with plank flooring for transporting rock or brush.

Accompanying this report is a statement of the year's expenditures.

The various details of the work were under the charge of Messrs. W. H. Floyd, jr., W. Henderson, and J. P. Kelly, whose assistance I desire to acknowledge.

I have the honor, Major, to be, very respectfully, your obedient servant,

D. W. CHURCH,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers.

S 10.

IMPROVEMENT OF MISSOURI RIVER AT BROWNVILLE, NEBRASKA.

Work was begun at this locality last summer, Assistant W. B. Hammond being in charge. Some preliminary operations were in progress

during the winter, and preparations were made for work in the spring on an extensive scale. This, however, proved impracticable and has necessarily been deferred to the present season. The appropriations have been so small that no great results can be anticipated, and only training works for the regulation of the channel will be attempted. Estimates heretofore submitted were approximate only, and a corrected one is herewith appended.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		11,254 23
July 1, 1881, amount available		8,745 77
Amount (estimated) required for completion of existing project		353,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		80,000 00

REPORT OF MR. W. B. HAMMOND, ASSISTANT ENGINEER.

BROWNVILLE, NEBR., *June* 30, 1881.

MAJOR: I have the honor to submit the following report of operations during the year ending this date, for improving Missouri River in vicinity of Brownville, Nebr.

A copy of the map made from survey of Captain Wellman, from Nebraska City to Aspinwall, was begun during the month of August. In August and September a careful survey of the river from Peru to 2 miles below Brownville was made and platted on the Wellman map.

The changes which have taken place in the immediate vicinity have been very nearly those forseen and predicted by your assistant, A. H. Blaisdell, in 1878, and Capt. Thomas H. Handbury, in 1880. The point which was above Brownville on the Missouri side has virtually disappeared; that portion of the town site formerly on the bottom land is now occupied by the river; the river in front of the town has now become so wide that a bar has formed in front of the town, which compels the ferry in low-water to land 1 mile below town. The Burlington and Missouri Railroad Company has built a wall at the base of its bluff embankments which prevents slidings, and have revetted 600 feet of shore in front of the town.

The general project for improving Missouri River in this vicinity, approved by the Chief of Engineers, contemplated the revetment of the left bank above and opposite Brownville, and the right bank below. Comparison of shore lines of 1879 and 1880 pointed to the conclusion that the appropriation was so out of proportion to the amount needed and called for that it would do little if any good if applied as proposed. Moreover, erosion had gone on so rapidly that the advisability of proceeding on the plan proposed was questionable. Accordingly a new scheme was sought whereby the expenditure of this meager sum might have its maximum effect. After a careful study and search for the causes which have produced the rapid changes in this vicinity, it was decided that Sonora Chute was the disturbing element. Coming suddenly on the main river at a section where it is moving straight toward the bluffs above Brownville, carrying a volume one-sixth the whole river, the chute strikes the river at right angles, and the resultant stream breaks up into several channels below, making a very difficult reach to pass in low-water.

A project for closing Sonora Chute by means of a pile-screen dike, starting above the chute and following the proposed shore line down, was approved by you January 20.

Previous to this, for experimental purposes, by your order of November 30, a stiff weed-dike—dike No. 1—was thrown across the chute. This was made of three weeds of the usual construction. One was 450 feet long, and the two others were 30 feet each.

The long weed extended across the stream; the two shorter ones were laid quartering up stream, lapping the long weed and extending up the bank. These weeds were built on the ice. When the weeds were completed, the ice was sawed out from under them, and they were dropped into the chute. The water was about 6 feet deep, and

the tops of the brush extended above the level of the ice. This method of construction would prove economical if it could be carried on in early spring, so that ice would not form around the weeds after placing and before the break-up. When the final break-up occurred, there was a thickness of 4 feet of ice and sand at the dike. The dike was partly sawed out, but it was found that to cut it all out would not be advisable from economical considerations. The chute gorged at the dike and took away both small weeds and over half of the longer one. Before putting in the dike, and for one month after, surveys were carefully made with pole through the ice, and failed to show any change attributable to the dike. Samples of the water showed it to be almost free from material in suspension. The fact that no change took place would tend to show that the quantity of material rolling along the bottom was also very small. The velocity had probably remained approximately uniform since soon after the river closed with ice, so that the material capable of being moved at that constant velocity had all been swept down. Either this or the material rolling along the bottom has heretofore been overestimated. These conclusions, it will be seen, suppose that the stiff weed is capable of retaining bottom-moving material when it exists.

The remaining work has consisted in the preparation and construction of plant. April 13, 1881, notice was received that the appropriation for 1881–'82 was made immediately available; the work of preparation since that date has had this in view. A project for the expenditure of this amount was approved by you May 20. This project contemplated dikes Nos. 2 and 3 as shown on map accompanying.

Four flat-boats and two skiffs have been constructed.

A machine for making wire net has been constructed and successfully operated. Photographs and drawings of this machine, accompany this report, and a description with statistics will be found in the appendix.

A quantity of rock probably sufficient for all dike work for the appropriations of 1880, 1, and 2 has been quarried and stored at a convenient place. Piles and wire net have also been stored in readiness for use when the pile sinker shall be placed at our disposal.

The reach which it was deemed necessary to consider in the expenditure of appropriation for 1880–'81 extends from Peru to 2 miles below Brownville. During February, 1881, surveys were made from Brownville to include the bend below Aspinwall, and by Assistant Engineer Potter, of Nebraska City, from that place to Peru. These surveys, being platted on the map of 1879, exhibited the changes taking place, and it was decided that the reach should extend from Otoe City to the bend below Aspinwall.

That portion of the reach between Otoe City and Peru was in 1867 and 1869 the scene of two remarkable cut-offs. The first was the more southerly and produced the greater effects, shortening the river by about 14 miles. The concentrated slope has been gradually distributed in both directions, but the slope above and below this cut-off is still excessive, from Peru to Brownville 1.1 feet per mile.

I am indebted to Captain Carey, who was the pilot of the first boat passing up the cut-off, viz, Colorado, for the following information: "The neck was very narrow for a distance of 1,000 feet, during a long time previous to the cut-off. Think it must have given way almost simultaneously throughout that distance. The cut-off occurred in the night. Left Peru the morning after the cut-off occurred. Knew nothing of the cut-off having taken place, and noticed nothing unusual until off the former neck. The cut-off had the appearance of a low reef or wier. Succeeded in passing up by following a slackwater chute on the east side. The current above the cut-off was very strong all the way to Nebraska City, the boat making only about one-third ordinary headway. One boat was sunk by the cut-off and another, after having traversed the old bend, was forced through the cut-off on attempting to pass it. One week after the cut-off took place, no difference in current above and below the cut-off was noticed."

The second cut-off was merely a cut-off of the old neck, and forming Hog-thief Island. It is noticeable that the river now runs in the channel east of Hog-thief Island in a direction opposite to that in which it ran before the cut-off took place. Had this second cut-off occurred prior to the date of the first one, it is probable that but one cut-off would have occurred, leaving the river in a much better condition than it now is. The second cut-off must have had little if any effect on the slope as the channel length was not thereby changed appreciably.

Coming to the more recent changes: Immediately below Otoe City the right bank is eroding very rapidly, causing great alarm among the property owners and necessitating the removal of the Burlington and Missouri Railroad track. The maximum cut from September to February, 1881, was 1,000 feet. The railway company has seriously considered putting in a dike for their own protection in this vicinity. The point in front of Peru has been continually narrowing and the river is gradually leaving Peru. The maximum cut on Peru Point from September, 1879, to February, 1881, was 400 feet. During the April rise of 1881 a heavy body of water ran across the point, but built up the point vertically from 1 to 3 feet. Surveys will probably show a heavy cut on the point during that flood. Very heavy cutting has taken place on

Sun Island during the spring. Below Brownville the erosion has been rapid on the right bank, necessitating the removal of the Burlington and Missouri Railroad Company's track. These recent changes are not shown on the map. Unless something is done to arrest these actions very grave results will follow, which may greatly complicate the problem of rectification.

The river at the present time on the reach under consideration is in very good condition for immediate improvement, there being no narrow necks liable to cut off in the near future; but it seems throughout to be just at the beginning of the formation of those deep bends which end in cut-offs.

On the accompanying map the divided channel has been platted, which it is believed will ameliorate all the above-mentioned undesirable conditions, and which will lengthen the river one-fifth of its present length, thereby reducing its slope so that the ordinary brush revetment will be sufficient to hold shore lines. The estimates given below are based on this plan of improvement.

The amount called for could not be profitably expended in one year. Probably about five years would be required to bring about the desired changes.

It is the more desirable that the reach should be immediately improved, as the several railroads now approaching the river in this vicinity will doubtless shortly locate a bridge at some point on this reach.

I hand you herewith profiles of ground water, so far as observed. These observations have been greatly hindered by high-water and subsequent condition of the bottoms.

Effort has been made to obtain information regarding bed-rock on the reach. The railroad companies now making borings here have not as yet complied with my request for profiles, but will probably do so when they have located their own bridge sites.

ESTIMATE.

94,000 feet of dike, at 75 cents	$70,500
106,000 feet of revetment, at $2	212,000
Total	282,500
Engineering, contingencies, plant, superintendence, surveys, care of plant, &c., 25 per cent. of above	70,625
Total	353,125

Length of rectified reach, 30 miles; cost per mile, $1,177.08; increase over present length, one-fifth.

Respectfully submitted.

W. B. HAMMOND,
Assistant Engineer.

Maj. C. R. SUTER,
Corps of Engineers, U. S. A.

WIRE-NET MACHINE.

The mesh which it was designed to make is triangular and appears when made as follows: A number of parallel wires with a diagonal zigzagging between each pair of parallels in such a way that three wires, two diagonals and one parallel, enter each intersection. The connection is a complete spiral and is right-handed throughout. It might, perhaps, be better described as a 3-threaded screw. The parallel does not remain straight while the others twist around it, but all three twist around each other in the same direction. The advantages of this mesh are more effective and economical distribution of wire, and rigidity of mesh. Regarding the intersection, it must be admitted superior to any pin-twist or other connection which depends for its strength on the simple rigidity of set of the wire in the connection.

The spiral connection is positive, and the net cannot be undone by any accident or any amount of rough handling. It is true that the pin-twist can be made so strong that the wire will often break before it will give way when under the first strain.

This, however, cannot be considered a fair test, as it is not to be compared for severity with the fatigue of the metal resulting from the vibrations which occur where the net is placed in the current. In order to give the pin-twist sufficient strength, the splice must be made at least double the length of the spiral twist, which is the cause of waste of wire, and changing triangles into trapezoids, squares into octagons, and diamonds into hexagons, with consequent loss of rigidity of mesh as well as of strength. The manner of making this net is as follows:

A number of vertical shafts are so arranged as to carry three spools of wire, one spool being stationary, the two others being fitted into cases with handles so as to be easily worked by hand. These shuttles are shifted back and forth between two parallels as desired, and when two shuttles come together the spindle is given two complete turns. The three wires are led on at the apices of an equilateral triangle and at

a distance of 1 inch from the center of the revolving shaft. When this twist is being made the wire from the spools plays out as required, twisting toward the machine so that the wire is not overstrained as is liable to be the case in the pin-twist. The routine of making the mesh is, twist shift shuttle, then reel up the net a distance half the base of the triangle. The distance of drawing out or reeling up every time regulates the size of mesh and perimeter which can be changed without any alteration of the machine at a moment's notice.

This machine was made very roughly from materials at hand and by a carpenter and blacksmith, and consequently has not been as effective as a more substantially-built machine would have been. How successful it has been may be seen from the table below. It has demonstrated the feasibility of making net in this manner, and has afforded valuable experience and suggested improvements which may be made another season.

This machine was arranged to put a cable edge on each side of net.

Mesh was equilateral, triangular of 18-inch altitude. Common laborers learn to do the weaving in 3 hours.

Statement showing work done on wire-net machine June 3 to June 10, 1881.

Date.	Total number of men working.	Men at shuttles.	Men at levers.	Foreman.	Total linear yield in feet.	Square feet per man per hour.	Square feet per hour per shuttleman.	Men filling spools.
Five hours, June 3	11	6	4	Not working	252	136.4	242	1
Five hours, June 3	9	4	4	....do	252	166	378	1
Five hours, June 4	10	5	4	....do	280	168	336	1
One and one half hours, June 4	10	5	4	....do	98	196.6	393.2	1
Five hours, June 8	11	6	4	....do	324	176.7	324	1
Five hours, June 8	12	7	4	....do	336	168	288	1
Four hours, June 9	13	8	4	....do	224	129	210	1
Five hours, June 10	10	5	4	....do	280	168	336	1
Four hours, June 10	11	6	4	....do	294	200	367.5	1

S 11.

IMPROVEMENT OF MISSOURI RIVER AT EASTPORT, IOWA, AND NEBRASKA CITY, NEBRASKA.

It had been my intention to use the small appropriation made for this locality on dikes designed for channel contraction and regulation. This work was to have been done in the spring, but was prevented by the excessive violence of the floods, which submerged the whole valley to a depth of 6 or 8 feet. In addition to this misfortune nearly all the work of previous years was swept away. This was entirely due to its unfinished condition and lack of proper extension. Nothing could be done to prevent it, as the banks were deeply submerged, and no brush or other materials accessible. As soon as possible work was resumed, and will be followed up as occasion offers, the main hope being to accomplish such diversion of the channel as will best protect the interests at stake. The situation is, however, a grave one, and the funds available entirely inadequate for the work absolutely necessary. This portion of river is an extremely difficult one to deal with, and nothing can be accomplished unless adequate means are provided to enable extensive work to be done with rapidity. A revised estimate is submitted herewith.

Assistant A. S. Potter has been in charge of this work.

This work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$14,618 20	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$34,618 20
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		16,136 16
July 1, 1881, amount available		18,482 04
Amount (estimated) required for completion of existing project		500,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

REPORT OF MR. ARTHUR S. POTTER, ASSISTANT ENGINEER.

NEBRASKA CITY, NEBR., *July* 28, 1881.

MAJOR: I have the honor to submit the following report on the work under my charge at Eastport, Iowa, and at Nebraska City, Nebr., during the year 1880 and 1881:

The details of the methods employed, appliances used, and results obtained are illustrated by photographs, drawings, and models. A list and description of drawings with incidental remarks, also certain statistics in regard to the cost of the work, will be sent in a few days as addenda.

On July 28, 1880, I arrived in Nebraska City, in accordance with instructions contained in your letter of July 26,1880, to relieve Assistant L. E. Cooley, August 1, 1880.

On August 1 a complete inventory was made of the property belonging to this work and incorporated in the property return for quarter ending September 30, 1880. In accordance with instructions contained in your letter dated July 30, a survey was made of the changes in this reach since previous surveys. As a result of the data obtained a project was submitted August 25, and approved September 15, 1880, according to which operations have been conducted as far as possible.

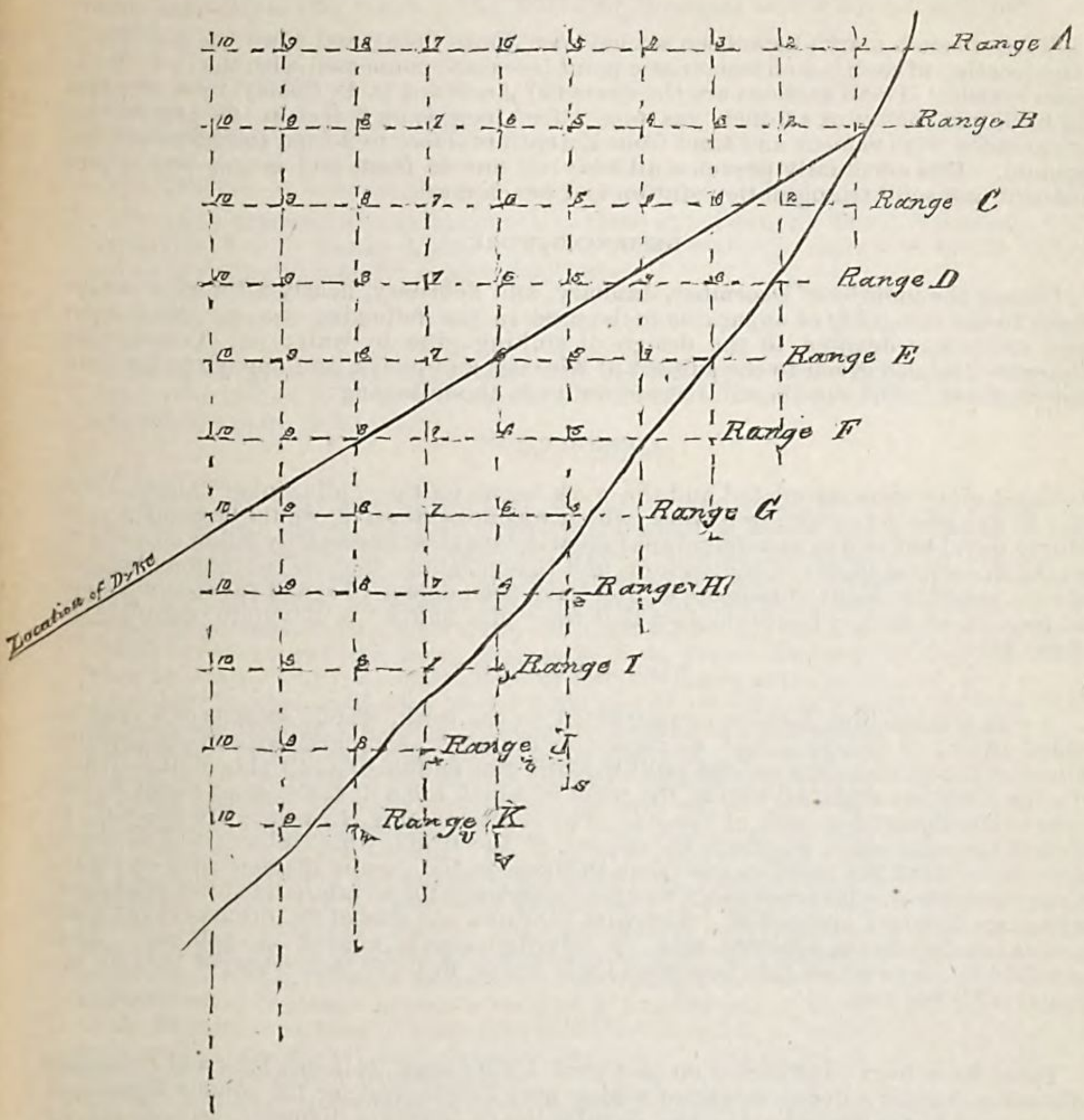
About October 25, a "low-water survey" from Jones' Point to Peru, a distance of 32 miles, was begun, the object of which was to obtain the accurate outlines of all cut banks and bars for comparison with the same of previous years. It has been our endeavor to carefully locate in this survey all old bench lines and shore lines of previous dates; also, to make careful note of the age of different benches and sloughs as nearly as it was possible to estimate by the age of trees growing in the vicinity and the well-sifted opinions of the oldest inhabitants. We are at present engaged in platting this survey. When the map is completed it will be reduced to a scale of 2,000 feet to 1 inch, and forwarded as a portion of the addenda to this report. At monthly intervals during the season, accurate cross-sections have been taken (each sounding instrumentally located) on sixteen ranges between Wyoming and this city. The ranges were regularly sounded before the closing, since the opening of the river, and twice during the winter through the ice, which was found in many places to be from 30 to 36 inches in thickness.

Slope was taken twice during the season from Jones' Point to Minersville Ice Slope February 9, and just after the verge of the April rise had passed, April 29. Only four of the benches to which the slope was referred have been accurately checked with the levels run by Assistant Phelps. The reliable completed data is shown in the following table; but, owing to the great distance between benches, the real distribution is not as accurately shown as desirable:

Ice-slope observations.

Date.	Gauge.	Jones' Point to Baker's.			Baker's to Neligh's.			Neligh's to City.			City to O. City.			Jones' Point to O. City.		
		Miles distant.	Total slope.	Slope per mile.	Miles distant.	Total slope.	Slope per mile.	Miles distant.	Total slope.	Slope per mile.	Miles distant.	Total slope.	Slope per mile.	Miles distant.	Total slope.	Slope per mile.
1881.	*Feet.*															
February 9	5.45	2	2.551	1.275	3.3	3.586	1.087	9.2	9.120	.991	8	8.981	1.122	22.5	24.238	1.08
April 29	15.42	1.866	2.645	1.417	3.08	3.741	1.214	8.586	10.071	1.168	7.466	9.057	1.257	21	24.75	1.178

A system of ranges and soundings has been devised for accurately ascertaining the silting effect of a dike when put in, and is briefly described and illustrated as follows': The accompanying sketch will make the system obvious, except perhaps the kind and



location of signals, which consists of a diamond-shaped wire frame 3 feet long and 2 feet wide, of number 10 bright wire, covered with thin white cloth stretched tightly, and the whole attached to a pole by barbed wire staples at top and bottom. The signals x, y, z, w, are set with their planes in such a direction as to be used on two ranges at right-angles to each other, but the back signals, s, t, u, v, &c., are set so as not to be seen except in the direction desired.

With this system confusion is impossible, and the soundings are located once for all on the corners of squares 100 feet on a side. They may also be taken on the line of dike and check on each range crossed. In this way a crew of unskilled men may do all the investigation of deposits without error as soon as the routine is learned.

GROUND WATER.

On March 20 arrangements were made for taking the heights of the bottom or ground water at different distances from the river as follows: ten wells were found in which readings might be taken located at nearly equal intervals across the bottom on what is known as the "Base Line Road," leading from the river at nearly right angles to its general direction 8.5 miles to the Iowa Bluff. A float with tape line attached (illustrated in addenda) was used to measure the height below certain bench marks on the curbs of the wells.

Only a few days subsequent to beginning the readings the water overflowed the bottoms, nearly depopulating them and filling the wells with silt. Hence no data of value has been collected.

BENCH MARKS.

Sixteen bench marks have been set between Jones Point and Peru on this reach. The location of each is a characteristic point (see map) connected with the D. W. Wellman system. These stations are the device of Assistant L. E. Cooley, used here also in 1879, and consist of a 2-inch gas pipe 8 feet long, sunk 7 feet in the ground, and surrounded with cement and sand from a depth of 6 feet to 2 from the surface of the ground. This effectually prevents all heaving due to frost, and makes both a permanent and solid triangulation station and bench mark.

DESIGNING WORK.

During the months of December, January, and February, nearly all work was confined to the designing of apparatus to be used in the following season. Much time and study was devoted to the design of sinking piles by water jet. Considerable thought was also given to the subject of wire net and buoys, and apparatus for their construction. The results will be referred to in the following:

CONSTRUCTION.

The designs were completed and the work begun on the "pile sinker" about April 1. It was hoped that the iron work, which was not extensive, would be completed in thirty days, but it was soon found that great delays must necessarily follow on account of the disastrous effects of high-water, and that machine shops were running beyond their capacity. Many shipments of iron have been delayed beyond the contract time at least two months; hence the fact that the "pile sinker" is not quite complete on June 30.

WIRE-NET MACHINE.

A wire-net machine has been constructed on the work, which consists of a twelve-sided drum, 40 feet long and 40 inches in diameter, arranged with studs passing through it along the lines of the radii through the middle of each side of the drum. To the studs are attached combs, the teeth of which are a distance apart equal to one side of the triangular mesh of the net. The studs carrying the combs are movable in line of the radii each way from the center of the drum, which allows the distance from the ends of the teeth on one comb to those on the combs diametrically opposite to increase 2 feet, which telescopic movement arranges for a variation in mesh area from $1\frac{1}{4}$ square feet to 2 square feet. The wire is put on one side of the drum as it revolves and is twisted on the opposite side. A selvedge man is needed on each end. It is possible to construct on this machine 1,000 linear feet (40 feet wide) of net in ten hours with ten men.

BUOYS.

There have been constructed on this work 1,250 buoys, 32 inches long and 12 inches diameter, having a displacement of a little over 2 cubic feet, or 130 pounds flotation. They consist of a frame having two circular heads 12 inches diameter, held apart by six studs, 1 by 1 by 30 inches, around which are rolled four layers of building paper tacked firmly to the edge of the heads, and the whole saturated in a mixture of boiling tar and rosin. The design of construction is the same as used by assistant L. E. Cooley, in 1879.

BARGES AND SKIFFS.

During the season it has been found necessary to construct one stone barge 8 feet by 40 feet, perpendicular gunwales, easy curved rake, and calked deck. This is furnished with sweep oars and sail, and is used for transferring material from place to place. One 6 by 30 feet barge used for launching katydid anchors in dike construction which is fully illustrated in the addenda. Two model lap-streak skiffs for light work and rapid transit along Missouri River.

BRUSH FENCE.

One thousand eight hundred feet of brush fence was placed on the bar opposite Neligh's, with the object of its construction, to act as a sand dike builder, to close a high-water slough of small capacity, and to furnish a header to the proposed dike to be laid from this point toward Neligh's. On account of the very wet fall and early winter the object for which the fence was built was not realized, when the early spring floods floated every vestige down the river. The method and design of construction is subject to many criticisms, and may be very much improved upon.

QUARRY.

A quarry was opened on May 25 in the bluff about one-quarter of a mile above Neligh's for the purpose of of obtaining rock needed in the construction of the dike work contemplated on this reach. The following amounts and kinds of rock have been quarried:

	Tons.
Anchor rock for net	307
Mattress rock	116.3
Katydid rock	10.4
Total	433.7

The great expense of obtaining rock in these quarries is the heavy stripping, which varies from 8 to 15 feet in depth. The use of the water jet here this fall is contemplated in stripping rock for next season's use.

WIRE NET.

During the year we have manufactured 251,900 square feet of wire net, varying in width from 22 feet to 50 feet, of numbers 13 and 14 annealed steel wire, mesh triangular, and 1½ square feet area.

BUOY DIKES.

When it was fully ascertained that the pile sinker would not sink piles until after high-water had pasesd, buoy-dike construction was at once started. It was thought last fall that it would be desirable to begin a dike on the edge of the bar opposite Neligh's and extend out to a point 1,000 feet from the Nebraska shore line, continuing from this point down parallel to the west shore line until the river followed the bluff line of Copeland's Bend, but during the high-water in April the entire bar opposite Neligh's was cut out to a depth of 20 to 25 feet; hence dike construction was begun at △ 11 (survey 1878), a continuation of the previously proposed line of dike.

On June 30, there had been placed 2,250 feet of net varying in width from 22 feet to 40 feet; the expense attending it is shown in detail in the financial statement.

Plant and apparatus are described in the addenda. Our experience would indicate that it is not desirable to put in buoy dike continuously, except normal to the current, as great difficulty has been experienced by both net and selvedge breaking from the continually increasing strain, brought to bear after a great length had been laid in one line parallel to the current. The strains of each element of the net, also that due to the cross-section of the buoys in the water, are transmitted indirectly to the lower selvedge. Then, again, there is no satisfactory way for drift to free itself when once in the net, except to tear through; if it does not do this the tendency is to strip the buoys from the net, which was repeatedly done with the paper buoys used this season, and experience proves them an undesirable construction except for very low-water, when the amount of floating material is reduced to a minimum. I am of the decided opinion that the shingle method of buoy-dike construction is far preferable to the continuous, but would suggest that each detached portion or shingle should not be less than 200 feet long or more than 100 feet apart.

The effect of the net placed was to begin the formation of a bar immediately above and below the dike and a rapid cutting out considerably above. This fill and cut is illustrated by a tracing on which is shown four series of soundings taken at nearly equal intervals, making the results of the bar-producing tendency of the net obvious.

BORINGS.

As the approved project called for the cutting of a new channel in Copeland's Bend, where no data had been ascertained as to the depth of rock, it was considered necessary to make rock soundings prior to starting work of rectification. Accordingly, in compliance with instructions in your letter, September 11, 1880, thirty-one drive borings and one sample boring were made at characteristic points. In order to obtain the desired information it was necessary to make many of the borings in the chute where the water varied from 6 to 10 feet in depth. The apparatus used was a boat 8 by 40 feet, decked with a 3-inch well-hole over which was erected a tripod 16 feet high, with an intermediate staging, also one on the top large enough to accommodate two men. Gas pipe, 1 inch diameter, cut in 8-foot lengths, was used, and to the upper length was secured a solid iron head to receive pounding from a wooden maul.

At first a steel point was considered necessary on the lower end of the pipe, with a bulge a trifle larger than the couplings to follow, but short experience taught the fact that the open pipe could be sunk with more rapidity, and in most cases a sample of the last stratum entered could be brought up. In each case the sounding was made

to a depth such that the friction of the material through which the pipe passed produced vibrations sufficient to neutralize the effect of the maul. From 55 to 60 feet was usually reached below the surface of the bottom land in the vicinity. The results of the soundings, in my opinion, prove conclusively that rock or heavy strata is not to be feared in the rectification of the river around this bend, even though the full proportion of the "ideal section" shown in your circular issued September 14 be realized.

PILING.

In December last, there were furnished this work by contract 26,012 linear feet of piling, varying in length from 26 to 45 feet, none of which have been used, and are shown as on hand in the recapitulation of the financial statement.

I will forward later as an appendix to this report, under the head of "Incidental Remarks," certain views relating to the present condition and past location of this reach of river and its improvement.

On the detailed financial statement which follows, each head is complete in itself, as the footings indicate.

The recapitulation shows under each head only the expense that has not been accounted for under other heads.

Very respectfully, your obedient servant,

ARTHUR S. POTTER.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 12.

IMPROVEMENT OF MISSOURI RIVER AT PLATTSMOUTH, NEBRASKA.

A re-survey of this locality was made in the fall, and arrangements were made for beginning work in the spring. These operations were delayed by high-water, and are but just being commenced, the present object being to remove the channel from the short bend in front of Plattsmouth, and to regulate its width and direction. This work will be followed up during the present season as far as the very limited appropriation will allow. The estimate herewith, based on the re-survey, is substituted for the approximate one submitted previously.

Assistant W. H. McKnew has been in charge of this work.

The work is in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$20,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		4,583 85
July 1, 1881, amount available		15,416 15
Amount (estimated) required for completion of existing project		214,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		70,000 00

REPORT OF MR. W. H. M'KNEW, ASSISTANT ENGINEER.

PLATTSMOUTH, NEBR., *July* 13, 1881.

MAJOR: I have the honor to submit the following report of the work of improving the Missouri River at Plattsmouth, Nebr., from February 1, 1881, to July 1, 1881.

Having accepted charge of the improvements February 1, 1881, my first work con-

sisted in making a low-water survey between head of Tobacco Island, 2.7 miles below Plattsmouth, to Jones Point, in all a distance of 12.8 miles. This was begun February 14, 1881, and completed February 23, 1881. Having completed survey, the next step of importance prior to beginning serious operations was the construction of plant, such as barges, skiffs, wire machine, equipment, &c.; also the collection of all necessary material and the organization of a sufficient force for operating.

There were built three barges, two 3 by 14 by 60 feet, one 3 by 10 by 40 feet. The larger two were constructed more substantial and heavier in every way than the smaller, being intended for heavier work.

Plate No. 1 illustrates the construction of the 60-foot barge, showing three transverse views, side elevation, and longitudinal section. A general description would be as follows: Exact dimensions over all 3 feet 4 inches by 14 feet by 59 feet; gunwales constructed out of 3 inches by 12 inches by 20 feet pine, bolted securely together, then rebolted through entire gunwales from bottom to top, making it as nearly as possible one piece. Bottom and deck were both planked longitudinally; the bottom plank at either end were sprung so as to make a curved rake of 7 feet 2 inches in length; midway between gunwales were placed double bulkheads, running fore and aft, and extending from deck to bottom, each constructed of 2 by 12 inches by 20 feet plank, and made fast to either side of vertical 4 by 4 inch posts placed at every alternate frame; midway between center bulkhead and gunwales were placed partial bulkheads made fast to vertical posts alternating with those running fore and aft through center.

Frames were made, one of 2 by 6 inches, braced for the greater part in both directions from center to upper corner of frame, and from lower corner to middle, butting against center bulkhead.

Three timber heads on a side securely bolted to gunwales and held near deck by iron rods five-eighths inch diameter passing through opposite timber heads. Barges when launched drew 5 inches; capacity when loaded to within 6 inches of deck, 60 tons.

The above description answers alike for both, with but one exception—that intended for carrying derrick and triple-geared capstan was stiffened with extra bulkhead running transverse, extending from deck to bottom, and distant from either end about 12 feet.

Small barge 3 by 10 by 40 feet, intended chiefly for light work, was put up with less regard to stiffness. Gunwales constructed of 3 by 12 inches by 20 feet, bottom and deck 2 by 12 inches with stiffened middle truss made entirely of 4 by 4 inches lumber; timber heads made fast same as described above. Corner irons were put on all barges constructed.

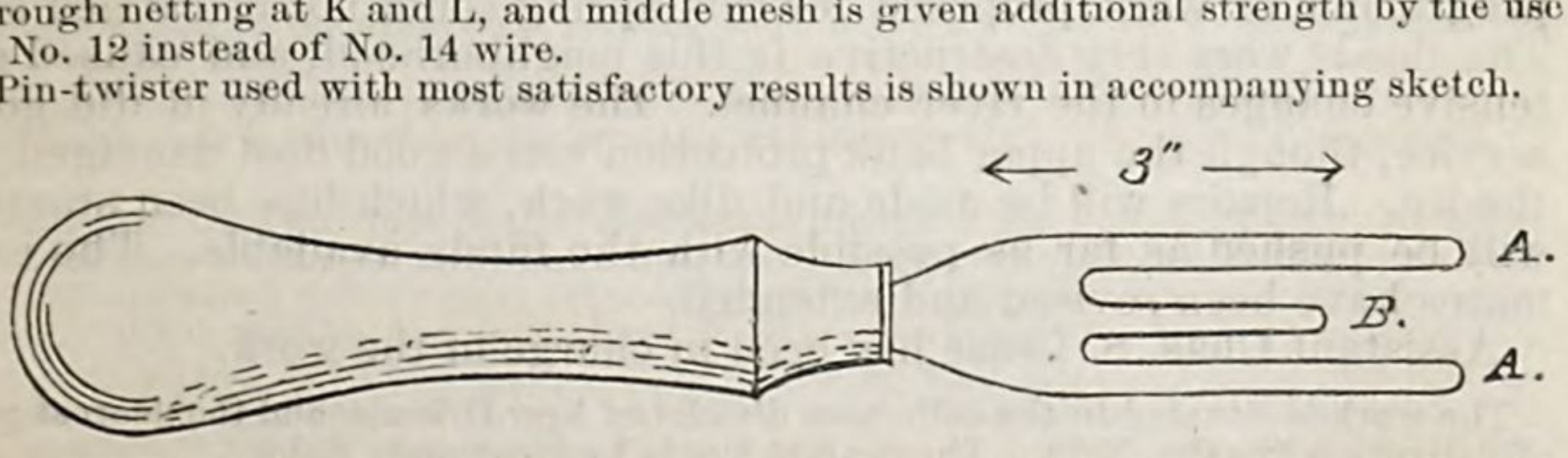
Skiffs have been constructed, their pattern not differing essentially from those commonly built out of wide lumber. Wire machine for the manufacture of wire netting with hexagonal mesh was constructed and is described as follows: The lower foundation frame is rectangular in form, being 6 feet 6 inches wide by 20 feet by 11 inches long. From front face spring three vertical posts notched to receive guide board, one at either end and one in middle. These are held in position near the top by a cross piece running parallel, and 6 feet 4 inches above bottom sill. On the tops of these vertical posts and extending back 18 inches are three horizontal pieces supported at either end by inclined posts.

The horizontal drum B C, 18 inches in diameter and movable on its axis, is supported by horizontal pieces, B C, resting on vertical and inclined posts; its sole function is in giving direction to the netting as it passes from front face to rear roller, H H.

J J is guide-board furnished with staples in front face 10 inches apart, each carrying one strand of wire from reel directly beneath to roller in rear. The reels are all separate, each having an axis of its own, consequently moving entirely independent. In order to secure requisite tension in the wire, straight springs were placed bearing hard on axle of each reel, thus accomplishing the purpose.

The men while twisting stand on the inside directly beneath the drum. Each edge is formed by twisting two No. 12 wires prior to entering machine. Extra wires pass through netting at K and L, and middle mesh is given additional strength by the use of No. 12 instead of No. 14 wire.

Pin-twister used with most satisfactory results is shown in accompanying sketch.



It is made entirely of steel, each arm, A A, being one-fourth inch diameter with center pin, B, one-fourth inch diameter at base and tapering somewhat towards point.

In operating, the guide-board occupies consecutively positions at O O O, P P P, Q Q

Q, R R R; thus without any movement of either drum or roller five linear feet or 100 square feet are manufactured, then with one turn of the machine it is wound on the rear reel, the guide-board again occupying its first position, and so on as before. The best day's work with unskilled labor, four men twisting wire and winding on roller with two men rereeling, was as follows: 600 linear feet or 12,000 square feet.

Cost of labor, six men, at $1.50	$9 00
Superintendence	2 00
	11 00
12,000 square feet, at .0009⅙	11 00
or 600 linear feet, 20 feet width, at .0183⅓	11 00

Wire used in the manufacture of netting Nos. 12 and 14 annealed steel wire, mesh 20 inches by 2 feet.

DERRICK.

A derrick as shown on Plate II was constructed for the sole purpose of placing tripods, frames, &c. A description would be useless, as a glance at the drawing will be all-sufficient for a clear understanding of it. Its safe limit of load as calculated from diagram is 10,000 pounds.

Owing to serious hinderance in the early spring, breaking up of ice and extreme high-water, we were delayed in the construction of plant and equipment; am therefore unable to report up to July 1 any construction work.

The improvements of the Missouri River at this point, owing to incessant changes above as far as Bellevue, will be confined chiefly to Plattsmouth Bend, building up a new shore, thereby rectifying channel between mouth of Platte River and Burlington and Missouri River Railroad Bridge, 1 mile below Plattsmouth. Changes which developed in reach by the extreme high-water of April 25, 1881, will be conducive to cheaper and more permanent improvements than could have been attained with any previously existing regimen of the past few years. The river has regained its old course through Saint Mary's Bend, and with little assistance at the lower end can be made to reverse its course in Pacific Bend, thereby aiding in maintaining proposed regimen below.

Owing to cut-off of 1880 and the development of Saint Mary's Bend, erosion of a temporary nature has been the result this season in Pacific Bend.

A system of tri-weekly well observations were instituted in June, 1881, in order to ascertain the rate and variance in level of ground water; these observations will be continued throughout the year until sufficient data has been collected. These observations when complete and coupled with gauge readings extending over same time will then show the desired relation between the two.

I am, Major, very respectfully, your obedient servant,

W. H. McKNEW,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 13.

IMPROVEMENT OF MISSOURI RIVER AT COUNCIL BLUFFS, IOWA, AND OMAHA, NEBRASKA.

Operations at this point were confined to repairs to old work, as the programme of work proposed for this spring could not be carried out. The floods were very destructive in this neighborhood, and caused extensive changes in the river channel. The works already in did good service, though the upper bank protection was a good deal damaged by the ice. Repairs will be made and dike work, which has been started, will be pushed as far as possible with the funds available. The estimates have been revised and extended.

Assistant Chas. S. Pease has been in charge of the work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$21,344 51	
Amount appropriated by act approved March 3, 1881	30,000 00	
		$51,344 51
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		13,720 13
July 1, 1881, amount available		37,624 38
Amount (estimated) required for completion of existing project		260,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

REPORT OF MR. CHARLES S. PEASE, ASSISTANT ENGINEER.

COUNCIL BLUFFS, IOWA, *July* 14, 1881.

MAJOR: I have the honor to submit the following report of operations in the vicinity of Omaha, Nebr., and Council Bluffs, Iowa, during the fiscal year ending June 30, 1881.

In obedience to your instructions in letter under date of August 14, 1881, I proceeded to Council Bluffs, Iowa, and on the 20th of that month relieved Assistant C. B. Davis in local charge of the improvements.

Comparing the general features of the situation with my recollection of those two years ago, the most marked changes had occurred in the lower half of the reach.

That these changes should have occurred was not difficult to causate, but hardly possible to foresee.

All may, it is thought, be traced to the cut-off of 1877 in the first bend above Omaha, as an initial cause. Many results have obtained from other immediate sources, but they are only links in the continuous chain whose first element was the great cut-off. Through many years may the chain be traced until it is lost in obscurity.

Though I have not been able to obtain much exact data, yet by comparing statements of several oldest inhabitants with observations on probable old water courses, sloughs, fast bank lines, &c., I can write the past history of the reach with considerable confidence.

There is every reason to believe that previous to about 1825 the river coursed from Florence through what is now known as Florence Lake, thence northeasterly across the present channel into the low ground just above the Chicago and Northwestern Railroad Company dikes, thence southerly along the bluff line through what is known as Iowa Lake. Through there it flowed almost directly west toward the Sulphur Spring, 3 miles above Omaha, and thence south through a short bend.

From Omaha to Bellvue any radical changes, if they occurred, have been effaced from the field, excepting perhaps the considerable hollowing of the vertex of K. C. bend. The earliest cut-off in the reach occurred in the old Florence Bend, leaving Florence Lake.

Probably this lake is very old, and it is becoming quite narrow and shoal. Land on the river side is slowly encroaching on it, and only a portion of the south and east sides bear evidence of having been high, limiting banks.

This gradual encroachment of the land, due to the deposit shoved over in the flood, is also shown, in varying degree, in Iowa and Cut-off Lakes.

The next event in chronological order was the cut-off which occurred in 1835, known then as Hart's Cut-off (Iowa Lake). We might go further back than the cut-off of 1877 and trace all changes to that in 1835. After the latter took place, a great erosion of the Iowa bank occurred opposite the break, and from the pockets thus formed the current crossed to the other side, causing the cutting which is yet evident at the vertex of the old bend, now called Cut-off Lake. These pockets, though of long radius of curvature, continued to deepen horizontally, until they developed into such extensive loops that a cut-off in one of them was inevitable. This finally happened in 1877.

For a long time previous to the latter event the reach had become so elongated that the local slopes were probably quite flat, and the regimen approached closely to that equilibrium which follows from extended period of exemption from disturbing occurrences. When the slender neck above Omaha separating two pools of considerable elevation at last gave way like a weak retaining wall the old equilibrium was destroyed and a new order of things quickly ensued. The Omaha front was eroded to the depth of 2,700 feet opposite the Union Pacific shops, and the channel shifted 1,000 feet westward from the cut-off to the bridge. A heavy bar of sand and gumbo was thrown up in front of the two limbs of the old bend, and in the four years since it has

been artificially built out, in order to relieve, in a measure, the undue sharpness of the new bend.

The excessive local slope of the cut-off distributed itself both up and down stream until an approximation to uniformity obtained. As a result of the increment of slope above the Chicago and Northwestern Railroad dikes, Willow Island Chute was formed, and in 1879 initiated the series of irregularities that have and will be very troublesome.

The current used to flow in a long, sweeping curve from about Tarbox Point to the entrance of Indian Bend. As soon as the chute began to discharge a considerable amount of water, the resultant direction of the flow from the chute and from the river outside the island was such as to cause a violent erosion of the bank opposite Iowa Lake. This deepened so much that in the fall of 1879 the current issued from it at almost right angles with its former direction in that locality, and crossed abruptly to the Nebraska side, where a long, shallow pocket was cut; thence back to the Iowa side below Gumbo Point, making another pocket there.

The flow reflected from this into Indian Bend, in a direction unfavorable to the attainment of a longer radius of curvature. The high-water of the spring of 1880 enlarged the chute and carried the foot of the lake pocket considerably down stream and caused a still further erosion of the Nebraska shore opposite. The situation below Gumbo Point, however, was very little changed.

The spring floods of 1881, exceeding, both in height and duration, those of former years, wrought some prominent alterations in the reach. A marked feature was the great tendency to straighten the channel way.

From Florence to the Chicago and Northwestern Railroad dikes a very direct course was maintained. Nooks and corners were filled with sand-bars. A chute which last fall carried nearly three-fourths of the discharge of the river was almost closed by an extensive deposit. The lake pocket was neglected, and leaving a heavy deposit in it the current swept by, carrying away the large bar existing for two years from the mouth of Iowa Lake to Gumbo Point. On the other side of the river, where the current had coursed for eighteen months, an extensive bar appeared after the subsidence of the flood.

Such, in general terms, is the history of the reach as far as known.

The works projected and accomplished for the rectification of the channel-way and preservation of the banks where valuable interests were at stake, have been fully discussed in previous reports.

The aim of the improvement-works in this vicinity has been to secure a permanent regimen, providing for navigation at all stages, and in so doing to meet the special requirement of an easy passage of the piers of the Union Pacific Railway bridge, by locating the flow under it in a direction normal to the line of that structure.

Though the object sought in the various projects submitted to you for the expenditure of the appropriations have had the same animus, yet in view of the many local changes from time to time, the details have been modified to meet the conditions imposed.

The first season's work under the provisions of the initial appropriations consisted in completing the revetment of the harbor of Omaha, begun by the Union Pacific Railway Company, and in revetting a large portion of the Iowa shore, above and below the mouth of Iowa Lake. Floating brush dikes were also constructed between Iowa Lake and Omaha with the aim of confining the flow to the left bank, which was revetted the same season. The next season, that of 1879, a floating brush dike of 1,750 linear feet was built in Indian Bend for the purpose of increasing its radius of curvature, and of creating a bank, which in time should be protected, relieving the constant danger of damage to the Omaha front, and providing for a better channel direction through the bridge. Extensive repairs were made to the revetment on left bank, and it was extended about 2,600 feet. About 1,800 linear feet of surface mat was constructed at the foot of the pocket, near Iowa Lake, to assist in holding the current over to the Nebraska bank. A short spur dike was also built at the point to aid in the same purpose. The Omaha revetment was extended south in order to prevent the recession of the shore line in that locality. In the spring of 1880, repairs were made to the Iowa and Nebraska revetments, and a wire-screen dike was built at Tarbox Point.

Such is an outline of the work executed previous to the fiscal year to which this report specially pertains.

As soon as the appropriation of August 14 was available, a thorough examination of the reach and of the condition of all the work was made. A project to make such repairs as were necessary for the preservation of the existing works, and to defer the construction of training works for channel rectification until the spring of 1881, met your approval.

MATTRESS WORK.

About 1,000 linear feet of the lower revetment of the Omaha front, constructed in 1878, by Assistant Boehmer, required renewal of high-water protection. As originally

built, this consisted of sectional mattress work under water, and a picket and wire fastened thatching above. This latter was much damaged and decayed during its three years of service, and required renewal for its full length. The first few mats had become badly frayed out, as at that point an eddy had formed under the lee of a projecting point. All the others, however, were in good condition. Accordingly, it was decided to throw out an apron over the damaged mats, and then to narrow up and carry along a continuous ribband of woven willows overlapping the line of mats and extending to the top of the bank. The woven willow matting has been used at several places along the river before, and full descriptions will be found in the reports of 1879 and 1880. The details of the work were as follows: A large patch of brush, of the quality most suitable for the work, was found on the Nebraska side, opposite Camp Richardson, 3 miles above. The brush was cut by corn knives, tied in 10-inch bundles, and hauled to the river bank by wagons. The launch Doris was not available at the time, and it would have been difficult and expensive to tow a barge up by land after taking a load down in it. Neither was it possible to haul the brush down by wagon, on account of the extensive mud flats near Cut-off Lake. A portable skeleton raft of joist and scantling was built and the brush loaded upon it in stable layers. Two men in a skiff ran it down to the working barge, and after all the bundles were taken off the frame was taken apart, loaded in a wagon, crossed over the river, and taken up opposite the patch. Here it was placed in a skiff, crossed over and put together for another trip; 24 cords of brush could be put on the raft, and with a full load, 6 feet high, about 15 inches floated above water. There was no trouble from the collection of mud in the load, as only a very small quantity was found. With a double line passed around the load, no difficulty was found in handling it in any water. All the brush for the repairs was very cheaply delivered in this manner

To serve as a platform for weaving and launching the mattress a 15 by 60 foot deck barge was moored at right angles with the current and provided on the upper side with a light system of ways.

The old grade was cleared of drift and loose willows, and in some places wash holes were filled up with earth. The mattress was begun on the bank and worked out over the water on the scow to a full width of 64½ feet. This width was carried to a distance of 219 feet, and covered the ground occupied originally by the frayed-out mats. The work was then narrowed down to an average of 42 feet, and continued to the lower end of the work, completely covering the bank and overlapping the old mats about 8 feet. This work averaged 8 inches in thickness, and was very closely and evenly woven, and covered an area of 4,907 square yards.

Willows of three-quarters of an inch in diameter seemed to give the best results. Short and small willows made up a flexible and tough mat, but the work goes on very slowly. Large willows make a strong mat, but not a tough one. The stalks are stiff, and the mesh cannot be made small enough so that they will bind in.

The launch Doris was sunk during a severe storm early in the spring of 1880, and although every attempt was made to raise her then they were unsuccessful. The wreck occurred at high-water, and when I began work on her last fall the sediment had completely covered the hull, and only a small arc of starboard paddle-wheel appeared above the surface. The high bold bank alongside was graded to a slope of 1¼ to 1 to provide for hauling her out when raised, and a coffer-dam of poles and brush built around her. A long ditch was dug to drain a pool beside the wreck in order that the work might be relieved of any seepage from it. As the material was excavated, it was found that the forepart of the launch was embedded in a motley collection of logs and small drift, making the excavation more troublesome. It was exceedingly difficult to keep the mud and quicksand and water from closing in and filling up the hole.

All the perforations in the hull were patched, and when the pumps were stopped the boat rose on the water in the pit. Her upper works were entirely carried away, and every vacancy in her machinery and boilers was packed full of sand and mud. The boilers and fittings were removed and placed under cover for the winter. This spring the launch was sent by your orders to the Western Iron Boat Building Company at Carondelet, Mo., for repairs, and was received there July 1, 1881.

SCREEN WORK.

The excessive floods of April, 1881, retarded very seriously the opening of spring operations. The water was so high that work was impracticable, even if material could have been transported to position. Through the winter it was expected to begin operations just as soon as the ice went out. But the ice did not start till April 27, and there followed a long period of excessively high-water, preventing advantageous operations. One good thing that the floods did was to partially close Willow Island Chute by a heavy sand-bar. Only a narrow mouth about 150 feet wide remained after the subsidence of the water. Fearing that upon falling water the main current would finally make its way through the chute, as it had a year ago, a screen dike was built across the water-way and a wire and brush fence over the bar to the main shore. It

was first thought necessary to support the screen from tripods, as the water was from 10 to 18 feet deep and the current about 5 miles per hour, but as the water fell on the crest of the bar at the head of the chute before the work was actually commenced the draw began to shoal up to an average of 8 feet.

The details of the work were as follows:

The supports chosen were equilateral triangles of 20 feet, sides made of cottonwood poles lashed at intersections with No. 12 wire. These were placed vertically in planes perpendicular to the dike line, and ballasted with a sand bag fastened to each inclined leg.

The peaks of the triangles were connected by a steel cable of five strands of No. 14 wire, which were anchored to dead men in the bank on either side. In a few hours the bases of the triangles were firmly embedded in the bottom and all was ready for the screen. This was made in hexagonal mesh 8 by 12 inches of No. 14 steel wire, and properly provided with selvages at each edge. From a small scow the air edge was attached to the suspension cable and the double-bailed rock anchors attached to the ground edge. The rootlets, willows, and other small drift began to collect rapidly, and the water soon shoaled to 2 feet. Length of dike, 550 feet.

The sand fence was then constructed, connecting the end of the screen work with the high bank. Frames of cottonwood poles were built about 4 feet high and placed 12 feet apart. Their tops were connected by a No. 12 wire, and down the face, which sloped up stream, three No. 12 wires were attached horizontally by staples and ran the full length of the work. The fence was then completed by weaving in stakes of willow brush between the wires. This fence was built for the double purpose of causing a deposit from the flood, which was expected to cover it, and in the fall of catching the wind-drifted sand. After the flood subsided it was proposed to re-enforce the face with tall willows in order to present more surface to the sand storms. Length of fence, 1,100 feet.

In accordance with the spirit of the approved general project a screen dike has been built from the Iowa side opposite the head of the Florence pocket. A large quantity of poles was found at Florence Point, a mile above the work, and again started at cutting them, and under the opposite bluff was found a fair deposit of shingle. The latter has and will be used to great advantage for ballasting the tripod and screen. The wire-screen machine was put in working order and a small stock made up for use. One of the scows, 15 by 60 feet, was fitted with a derrick to handle the tripods, and provided with a new capstan and gypsy windlass.

The operation of the outfit as far as the work has progressed is as follows:

Three poles, 4 inches in diameter and 16 feet long, are laid on deck and lashed together in the form of an equilateral triangle 5 feet on a side. Then three other poles, 25 feet long, are lashed at each corner of the triangle and their tops brought together over the center of the base and securely fastened together with wire, making in all a right-triangular pyramid about 23 feet high. One two-bushel sand bag weighing 300 pounds is attached to each leg as ballast. The hook of the differential pulley at the peak of the boom is then attached to the tripod, which is swung clear of the deck and dropped into position on the bottom. Where the current is deep and strong the tripods are braced at about half-way up the side with three poles, each joining two legs.

The tripods are placed about 30 feet apart, and in a straight line inclined a little out, and down stream from a normal to the current. The tops of the tripods are then connected with a No. 8 suspension wire, on which the screen is finally hung. These lines of tripods are placed in sections of about 150 linear feet, so that if a log or rack heap should run into the dike only a small portion of it would be destroyed. From the end of the completed section, the side line always runs to the working scow parallel with the line of the next section. From this line is hung by two ropes a small lighter containing bailed rock for the screen anchorage. The screen is brought out from the shore in a roll, and from the lighter both attachments are made and the ground edge is dropped overboard. Little of this kind of work has been done this season, and the above method will not probably be in order for the whole season's work. New appliances and methods are being discussed, and the main considerations of dike-work, efficiency, facility of rapid placing, and economy, are kept always in view. A considerable fill is observed above and below the work, but not nearly as much as would have occurred had it been possible to begin in time to get the benefit of the high-water.

It will probably be premature and misleading to record the few observations made upon the small amount of work already in place as applying to screen-dike work in general. A few memoranda may be given, however. Through June on falling water there seemed to be a large amount of rootlets, grass, and willows in transit, equaling in amount that usually found at the same stage of the water of late years.

After the tripods have been in place for a few hours they begin to settle, often to the amount of 3 feet. So far the settlement has been uniform in amount at all corners. There is, also, observed a slow movement down stream, about 3 to 5 feet in all, before they become permanently fixed. Length of work, 600 feet.

SURVEYS.

Examinations were made from time to time to show the extent of the erosion of the bank at the head of the Iowa revetment, and along the opposite shore.

There being no map embodying the varying shore lines since the spring of 1879, it was deemed advisable to construct a large scale map which would show all the important changes in the river since that time, and give the location of all the work executed. This map was constructed in the fall and winter upon a scale of 400 feet to 1 inch. During October a low-water survey was made, including gauging, soundings, and slope observations. That survey was platted both in the 1,000 feet and 400 feet scale maps. The gauging and sonnding notes are also worked up, and are on file. A survey of the lower portion of the reach, extending from the Union Pacific Bridge to Bellevue, was begun on February 24, and was completed March 6. The ice was hard and fast from bank to bank, so that the field work was confined to the location of shore and bar lines and general topography, to the exclusion of soundings and levels for slope. A map of this survey has been submitted to you with letter under date of June 20, 1881. The complete reconnaissance of the reach was made soon after the floods, and a report with sketches, &c., submitted.

THE FLOODS.

A severer winter has not been known along the Missouri River, since the country was settled, than that just passed. There occurred no January thaw as in the previous years, and the weather, save at few and short intervals, was exceptionally cold. Ice formed to the thickness of 24 to 32 inches in the river here; and indeed at Yankton, Dak., after the break-up, 36 to 50 inch cakes were left ashore by the water. After the middle of March the weather was comparatively moderate, and it was predicted that when the break-up so long deferred finally came, great floods might be expected, and so it proved.

Through February the gauge read about 8.5 feet. About the 1st of March a gradual rise was seen. From the 10th to the 16th it rose very fast, and remained about stationary for a few days after the latter date. From the 24th it rose very rapidly, until the ice was in full flow on the 27th. The ice began running on a stage of about 16 feet, and the water fell back for a day or two to 14 feet. On April 1 it began to rise again, and reached a height of 22 feet on the 9th. From this point the water fell uniformly to 15 feet on the 16th, and then rose in eight days to the highest recorded flood stage of 23 feet 9¾ inches. From this point the water fell as rapidly as it came to 12½ feet on May 2, and oscillated between 9 and 11 feet until the 1st of June. The crest of the June rise, if so it may be called, came on the 15th of that month, when it rose to 14 feet, slowly receding again to 11 feet, and remaining about stationary for the rest of the month.

The effects of the floods were very disastrous, and will long be remembered. The water began to overflow the proper banks generally at a stage of 18 feet, and finally the bottoms were covered from bluff to bluff, with the exception of a few high points.

The damage to the revetments was confined to the Omaha front, and there only above the ice-line. A levee to support the high-water protection had been raised when the work was put in, and this was nearly all leveled, as it was covered by the waters of both floods. It is proposed to make all necessary repairs next fall, when such work can be done to the best advantage.

A very unfavorable result of the floods was the cut-off in Kansas City Bend, April 26. This neck was about 1,200 feet wide when the survey was made in that vicinity last winter. On the upper side was about 3½ miles of almost perfect river, having a narrow and deep section, and flowing in banks regarded as permanent for ten years previous. The river was shortened about 4½ miles, and the difference of level on the two sides was about 31 feet.

A violent erosion of the Iowa shore opposite the cut soon resulted, and has not yet ceased.

This is the third cut-off between Omaha and the Platte River in the last three years.

GROUND WATER OBSERVATIONS.

In order to determine the rate of variation of the level of the ground water, measurements have been made of the stand of several wells upon the bottom, and the results platted upon the accompanying chart.

The bridge-gauge curve is platted above, and the well curves follow in the order of distance from the river.

I have been ably assisted during the year past by Messrs. James W. Pearl, John A. Ferris, and William H. McKnew, assistant engineers; the latter in charge this season at Plattsmouth, Nebr.

I am, Major, very respectfully, your obedient servant,

CHAS. S. PEASE,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 14.

IMPROVEMENT OF MISSOURI RIVER AT SIOUX CITY, IOWA.

At this place, as at others, the work which it had been proposed to do in the spring was stopped by the violence of the floods. A careful resurvey has enabled us to fix upon the lines to be given the regulated river, and permeable dikes to accomplish the desired result will be put in as soon as possible, to the extent of the funds available. The old work has stood well, and will need but trifling repairs. An extension of the ground covered by the improvement is judged necessary, and the estimates are revised accordingly.

Assistant S. H. Yonge has been in charge of the work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$8,401 34	
Amount received sales of fuel to officers	34 87	
Amount allotted from appropriation for survey of Missouri River from its mouth to Sioux City, Iowa, &c., act approved June 14, 1880	4,000 00	
Amount appropriated by act approved March 3, 1881	7,000 00	
		$19,436 21
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		8,359 00
July 1, 1881, amount available		11,077 21
Amount (estimated) required for completion of existing project		560,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

REPORT OF MR. SAMUEL H. YONGE, ASSISTANT ENGINEER.

SIOUX CITY, IOWA, *June* 30, 1881.

MAJOR: For the fiscal year ending June 30, 1881, I beg leave to submit the following report:

I was instructed by your letter of August 17, 1880, to make a survey of the reach above Sioux City, to enable a study of the river to be made, so as to determine the nature and extent of works necessary to insure stability of river at Sioux City and of the works already built and projected there.

This survey was commenced September 14 and was completed in the latter part of October. It extended from Iowa Creek to the mouth of Big Sioux River, and showed a tortuous river in a very unstable condition.

Its length by the low-water channel is about 27 miles, while in a direct line it is only 10½ miles. The maximum slope of water surface observed was 1.3 feet per mile; the average slope for the whole distance is 0.781 foot per mile.

A comparison of the length of the channel, when the cut-off shown on the map was occupied by the river, with the length of the present low-water channel, shows that the river has regained the length lost when the cut-off occurred.

This reach is in a condition susceptible of permanent improvement at comparatively small cost; unless this is effected in the near future the narrow necks of land with cutting banks will become a series of cut-offs which will cause changes of regimen and produce an unsettled condition of river above and below indefinitely.

The severity of the past winter caused the formation of ice of unusual thickness. Spring began in Northern Montana and Dakota earlier than in this locality, causing the river to open at Fort Buford while the ice below was still intact. In March an immense volume of snow water came suddenly down the river, and breaking up the solid ice, which was in many places from 3 to 4 feet thick, caused numerous gorges to form between Fort Pierre and this point.

I visited the first gorge above Sioux City, but could only make a brief reconnaissance owing to the deep snow and the overflow of the bottom lands rendering the roads almost impassable. The gorge formed on the shallow crossing in the vicinity of section 15, and extended up stream an estimated distance of 15 miles. The river was choked by a vast mass of broken ice, open in places with a perceptible current of comparatively clear water flowing through. The result of this gorge was an almost complete overflow of the valley, which is here common, with that of the Big Sioux River, and is about 14 miles wide. The water ran in swift currents through high-water sloughs which had not been water carriers for probably two or more decades. The velocity of these currents in some cases must have been very high, as evidenced by the scour of the ground. A large part of the water flowing across the valley found an outlet through the Big Sioux and a portion over the bank into the river below the gorge.

It is highly probable that many erratic changes in the river bed, indicated by old bank lines, have been caused by gorges in former years. I am inclined to believe that the shallow crossings, by impeding the free movement of the ice, are the direct cause of the formation of gorges. Such a condition of affairs, evidently, could not exist were a general improvement of the river carried out.

The disastrous consequences of overflows resulting from gorges, though severe during the past season, will be greatly intensified when the fertile bottom lands have become more thickly settled. The loss to stock and damage to farms and railroads from the overflows between Fort Pierre and Sioux City this season is estimated at from $750,000 to $1,000,000.

After a careful consideration of the subject, I have come to the conclusion that it would be impossible to give relief by the use of explosives or other means, after the formation of these gorges, except at enormous expense, as the ice from above would pack faster than it could be removed from below by any ordinary means.

Notwithstanding the difficulties of navigation and its attendant dangers, the amount of business carried on by river from Sioux City is large and important. During the six months' season of 1880 it aggregated 26,000 tons or 2,600 car loads, equal to a train of cars 15 miles long. Although the railroads have extended their lines to Fort Pierre and other points on the upper river, the probabilities are that the business by river this season will be equal in amount to that of 1880. This is an indication of what might be expected in the event of a permanent improvement of the river, with the dangers of navigation reduced to a minimum and the inhabitants assured against overflows and the washing away of their lands and property.

The remarkable event of the year was the unprecedented high-water in April; this exceeded anything known for twenty-four years, which is as far back as the records extend. This flood continued above the high-water mark of 1857 from midnight of April 20 to noon of April 26, a period of 132 hours. During this time the flow of water extended across the greater part of the valley. When the river fell deposits of sand were left over large areas, amounting in some cases to 5 feet in depth. This flood has been followed by a prolonged stage of medium high-water, which has not attained the height of the usual June rise by 3 feet. In this connection may be cited the great variation of discharge, which, during the past year, ranged from about 10,000 to probably 450,000 cubic feet per second, the oscillation of the gorge being 18.7 feet. These extremes of low and high water will undoubtedly be lessened as the valley becomes thickly settled. In this part of the northwest it has been proved that the planting of trees and bringing new land under cultivation has a marked influence in distributing the rain-fall more uniformly throughout the year. The breaking of the land, permitting the rain and melted snow to permeate the soil, prevents the instantaneous flow, as it were, from the hard surface crust which covers the unbroken prairies. These views are presented, as they are believed to have an important bearing on the subject of the permanent improvement of the river.

The works at Sioux City remain in serviceable condition. A portion of the continuous woven mattress on the Nebraska shore above low-water suffered some damage from the movement of the ice in March, and a slight bank cutting on that line resulted during the high-water of April. Slight repairs have been made, which, it is believed, will suffice to hold the bank against further erosion. The low-water portion of the mattress appears to be in excellent condition.

This work has now withstood three floods and the breaking up of the ice of two seasons without suffering serious damage. The effect of the moving ice on the bank revetment may be realized from the fact that cakes of from 2 to 8 acres in extent and from 2 to 4 feet thick were constantly thrust against it by the current during the break up in March. In addition to the repairs mentioned there have been manufactured about 50,000 square feet of wire netting and three barges have been built for carrying machinery to be used in this season's operations.

Although it was expected that the projected training-works could be constructed before the June rise, it has been impossible to do so owing to the unavoidable delays

in procuring lumber and other materials caused by the interruption to railroad traffic by snow and floods during the spring.

This report is accompanied by a tracing of the map of the river from Iowa Creek to Floyd's River and a sheet of low-water cross sections of this reach of river; also a table of areas of these sections.

Attention is called particularly to the two sections Nos. 15 and 36; to the former on account of its great width and shallowness, which has already been alluded to as the cause of the formation of a gorge, and to the latter on account of its narrowness and depth, showing the possibility of contraction at low-water in this reach of river.

In conclusion, I would state that I have been ably assisted in various field and office duties by Mr. D. W. Kinnaird until January 1, 1881, and since then by Mr. R. H. Bacot and Mr. A. H. Weber.

I have the honor to be, very respectfully, your obedient servant,

SAML. H. YONGE,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Table of area of sections, &c.

Number of section.	Elevation of Sioux City gauge.	Discharge per second in cubic feet by formula.	Area of section in square feet.	Width, not including bars above water.	Mean depth of section.	Mean velocity in feet per second calculated.	Slope between sections measured.	Slope per mile.
	Feet.			*Feet.*	*Feet.*		*Feet.*	
1	84. 84	24, 250	8, 972	1, 645	5. 454	2. 702	.....	.....
2	84. 84	24, 250	7, 540	940	8. 024	3. 215	0. 243	0. 692
3	84. 84	24, 250	9, 081	900	10. 090	2. 670	0. 280	0. 770
4	84. 84	24, 250	10, 451	1, 360	7. 684	2. 320	0. 127	0. 327
5	84. 84	24, 250	10, 650	1, 750	6. 085	2. 277	0. 319	0. 876
6	84. 84	24, 250	8, 438	1, 540	5. 479	2. 874	0. 550	0. 267
7	84. 84	24, 250	12, 294	1, 695	7. 253	1. 973	0. 087	0. 302
8	84. 84	24, 250	9, 373	1, 740	5. 386	2. 587	0. 075	0. 264
9	84. 84	24, 250	7, 874	1, 090	7. 223	3. 079	0. 362	1. 082
10	84. 96	24, 800	8, 940	720	12. 416	2. 785	0. 213	0. 449
11	84. 96	24, 800	8, 569	710	12. 069	2. 894	0. 161	0. 369
12	84. 96	24, 800	11, 025	1, 100	10. 022	2. 249	0. 219	0. 376
13	84. 96	24, 800	10, 312	1, 050	9. 820	2. 404	0. 273	0. 417
14	84. 96	24, 800	10, 247	1, 600	6. 404	2. 420	0. 536	1. 277
							Reverse.	Reverse.
15	84. 96	24, 800	13, 778	2, 340	5. 888	1. 799	0. 073	0. 226
16	84. 96	24, 800	9, 966	1, 960	5. 084	2. 488	0. 247	0. 601
17	84. 96	24, 800	10, 963	1, 570	6. 982	2. 262	0. 406	1. 019
18	84. 96	24, 800	9, 320	650	14. 338	2. 660	(*)	(*)
19	84. 96	24, 800	9, 694	730	13. 279	2. 558	0. 787	0. 929
20	84. 96	24, 800	12, 094	1, 260	9. 598	2. 049	.....	.....
21	84. 96	24, 800	9, 947	910	10. 930	2. 493	.....	.....
22	84. 96	24, 800	9, 832	980	10. 032	2. 522	0. 505	0. 471
23	84. 96	24, 800	9, 791	1, 030	9. 505	2. 533	.....	.....
24	84. 96	24, 800	13, 371	880	15. 194	1. 854	.....	.....
25	84. 96	24, 800	10, 070	1, 030	9. 776	2. 462	.....	.....
26	84. 96	24, 800	9, 413	1, 600	5. 883	2. 634	.....	.....
27	84. 96	24, 800	10, 403	1, 300	8. 002	2. 384	1. 404	0. 665
28	84. 96	24, 800	10, 236	1, 370	7. 471	2. 422	.....	.....
29	84. 96	24, 800	11, 381	1, 600	7. 113	2. 179	0. 501	0. 528
30	84. 96	24, 800	9, 145	1, 520	6. 016	2. 711	0. 184	0. 586
31	84. 96	24, 800	12, 499	2, 150	5. 813	1. 984		
32	84. 86	24, 300	7, 648	1, 000	7. 648	3. 177	0. 986	0. 908
33	84. 86	24, 300	7, 270	650	11. 184	3. 342	0. 429	0. 702
34	84. 86	24, 300	9, 860	2, 160	4. 565	2. 464	.....	.....
35	84. 86	24, 300	9, 814	1, 450	6. 768	2. 476	.....	.....
36	84. 84	24, 250	7, 048	300	23. 493	3. 440	.....	.....
37	84. 84	24, 250	8, 770	1, 250	7. 016	2. 765	.....	.....
38	84. 84	24, 250	10, 114	1, 310	7. 720	2. 397	.....	.....
39	84. 80	24, 050	6, 400	600	10. 666	3. 757	.....	.....
40	84. 80	24, 050	8, 062	450	17. 915	2. 983	3. 430	0. 934
41	84. 80	24, 050	6, 735	740	9. 101	3. 570	.....	.....
42	84. 80	24, 050	5, 602	610	9. 183	4. 293	.....	.....
43	84. 80	24, 050	8, 385	770	10. 889	2. 868	.....	.....
44	84. 80	24, 050	7, 234	860	8. 411	3. 324	.....	.....

*Not observed,

Table of area of sections, &c.—Continued.

Number of section.	Elevation of Sioux City gauge.	Discharge per second in cubic feet by formula.	Area of section in square feet.	Width, not including bars above water.	Mean depth of section.	Mean velocity in feet per second calculated.	Slope between sections measured.	Slope per mile.
	Feet.			*Feet.*	*Feet.*		*Feet.*	
45	84.80	24,050	9,934	1,380	7.126	2.420	.....	.....
46	84.80	24,050	8,847	930	9.513	2.718	.....	.....
47	84.80	24,050	8,390	1,200	6.991	2.866	.....	.....
48	84.80	24,050	9,617	1,510	6.368	2.500	.....	.....
49	84.66	23,450	8,562	1,080	7.927	2.738	.....	.....
50	84.66	23,450	.....	.....	.....	.....	.....	.....
51	84.66	23,450	8,472	950	8.918	2.766	.....	.....
52	84.46	22,575	8,902	1,320	6.744	2.535	.....	.....
53	84.46	22,575	7,123	800	8.903	3.169	.....	.....
54	84.46	22,575	7,951	890	8.933	2.839	.....	.....
55	84.46	22,575	7,672	990	7.749	2.942	.....	.....
56	84.46	22,575	6,542	730	8.961	3.450	.....	.....
57	84.46	22,575	7,695	1,000	7.695	2.933	.....	.....
58	84.46	22,575	8,469	1,040	8.143	2.665	.....	.....
59	84.46	22,575	7,499	980	7.652	3.010	.....	.....
60	84.46	22,575	9,460	1,400	6.757	2.386	.....	.....
61	84.46	22,575	6,684	1,410	4.740	3.377	.....	.....
62	84.46	22,575	11,416	980	11.648	1.977	.....	.....
63	84.46	22,575	9,795	1,110	8.824	2.304	.....	.....
64	84.36	22,200	9,177	950	9.660	2.419	8.937	0.960
65	84.36	22,200	8,121	710	11.442	2.732	0.057	0.681
66	84.36	22,200	8,321	685	12.147	2.667	0.070	2.048
67	84.36	22,200	5,996	650	9.224	3.702	0.141	1.618
68	84.36	22,200	6,826	650	10.501	3.252	0.341	3.099
69	84.36	22,200	5,724	575	9.954	3.878	0.340	3.590
70	84.36	22,200	7,123	700	10.175	3.116	0.196	2.460
71	84.36	22,200	9,909	950	10.430	2.240	0.200	1.953
72	84.36	22,200	8,693	1,100	7.902	2.553	0.338	2.228
73	84.36	22,200	.....	.....	.....	.....	0.342	3.611
74	84.36	22,200	9,117	1,360	6.703	2.435	.....	.....
75	84.36	22,200	7,649	1,350	5.666	2.902	.....	.....
76	84.36	22,200	7,895	1,100	7.177	2.812	.....	.....
77	84.36	22,200	7,430	700	10.614	2.988	.....	.....
78	84.36	22,200	6,700	940	7.127	3.313	.....	.....

Total slope from Iowa Creek to Floyd's River, 24.6 feet. The areas of sections in this table were calculated from soundings taken at random which were not located by angles from bases.

S 15.

IMPROVEMENT OF MISSOURI RIVER AT VERMILLION, DAKOTA.

It had been proposed to expend the money available for this work during the spring of 1881 in regulating the channel of the river in the vicinity of Vermillion, and especially in preventing a threatened cut-off just above the town. During the floods which followed the breaking up of the ice, and which inundated the whole valley, the cut-off alluded to took place, and a complete revision of the plans has been necessitated. Estimates for the new project are submitted herewith. During the present season, work directed to the regulation and contraction of the channel will be pushed as far as possible.

Assistant C. F. Potter has been in charge of this work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1881, was $2,845.56.

Money statement.

July 1, 1880, amount available	$10,002 15	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$25,002 15
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,417 01
July 1, 1881, amount available		19,585 14
Amount (estimated) required for completion of existing project		113,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		70,000 00

REPORT OF MR. CHARLES F. POTTER, ASSISTANT ENGINEER.

VERMILLION, DAK., *July* 9, 1881.

MAJOR: I have the honor to make the following report for the fiscal year ending June 30, 1881:

By your letter dated September 10, 1880, I was placed in local charge of the works of improving the Missouri River at this place. Under your direction a survey of 29 miles of the river was made during the months of October and November, 1880. This survey extended from the mouth of Bow Creek to a point 1 mile below Butler's Landing.

The work of the survey was greatly impeded by a heavy fall of snow October 15, and by the stormy weather which followed. By the survey two problems were presented, differing somewhat, but both of vital character.

The first and most important was the relative danger threatening the town of Vermillion from a washout at the next rise of the river.

The second was the threatened cut-off near Douglas Mill, which would in effect shorten the river 11 miles.

The available money being insufficient to protect both interests it was deemed expedient to turn our attention to the protection of the town. To accomplish this purpose, it was proposed to construct a training dike 3,300 feet in length, consisting of wire screen, supported by piling in a position shown at 1, 2, 3, on accompanying map, and thus turn the channel of the river back into the chute, south of Vermillion Island. This plan meeting your approval in February, an effort was at once made to get the required plant in readiness to commence operations immediately after the ice should move out.

The long-continued snow blockade, however, rendered it impossible to obtain the necessary material for the boats. Closely following the snow blockade came the flood with its disastrous results.

The severe winter had given to the ice the unusual thickness of from 36 to 42 inches in this vicinity, and its strength was so great that a sudden rise of 6 feet failed to break it up for several days; but on the night of March 27 a break occurred, and almost immediately a gorge formed in front of the town of Vermillion, causing the town to be flooded to a depth of 3 feet. Four days later a gorge formed about 8 miles above the mouth of Bow Creek in Saint Helena Bend, in such a position as to turn the Missouri from its former bed down over the bottom, and coming again into the old channel at Vermillion.

From March 31 to April 10, the water and ice covered the entire valley to a depth of from 6 to 10 feet.

For a time the indications were that an entirely new channel would be made over a considerable portion of this reach; this change was prevented, however, by the great depth to which the ground was frozen, with the single exception of the cut-off near Douglas Mill.

This change took place on March 31, the ice making two channels, and leaving a narrow island which was soon washed away. This cut-off shortened the river 11 miles, and Vermillion was left an inland town. Another feature is noticed, in that the river does not now come in contact with the left bluff after it leaves Yankton until Sioux City is reached. The difference in level of the water surface on opposite sides of this neck last November was 8 feet.

The excessive fall had so distributed itself by the last of April that steamboats experienced but little difficulty in taking this course up stream.

The changes caused by the overflow necessitated the making of a re-survey, which was completed June 12. The former plans being now of no value a new project was submitted June 18, 1881, and arrangements are now being made for carrying it out.

The work now contemplated will commence 1 mile below Bow Creek and will consist of 10,500 feet of training-dikes, 2,000 feet of cross-dike, and 5,000 feet of revetment.

The improvements will conform to a general plan for the complete rectification of the river between points indicated by A and B on the map, and which will depend upon future appropriations for its completion. It is thought that with the money now available, the desired rectification can be carried 3 miles. The following table will show the effect of the cut-off on the slope of this reach, from observations taken at the points designated by A, B, and C, on October 30, 1880, and June 18, 1881:

Date.	Elevations.			A to B.			B to C.			A to C.		
	A.	B.	C.	Distance in miles.	Total slope.	Slope per mile.	Distance in miles.	Total slope.	Slope per mile.	Distance in miles.	Total slope.	Slope per mile.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*		*Feet.*	*Feet.*		*Feet.*	*Feet.*
October 30, 1880	88	78.9	68.8	12.3	9.1	.74	16.7	10.1	.6	29	19.2	.66
June 18, 1881	94.1	82.2	77.4	12.3	11.9	.97	5.7	4.8	.84	18	16.7	93

	Feet.
Gauge reading at Vermillion, November 22, 1880	5
Gauge reading at Vermillion, April 6, 1881	21
Range between high and low water	20.5

I am, Major, very respectfully, your obedient servant,

CHAS. F. POTTER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

S 16.

IMPROVEMENT OF MISSOURI RIVER, BETWEEN KANSAS CITY AND ITS MOUTH.

The appropriation under this head of $35,000, will be expended on snag-boat work, of which about eight months will be accomplished. The estimates for continuing that work during the fiscal year ending June 30, 1883, have already been given under the usual head, and with the other estimates for snag-boat work on the Missouri.

The following estimate is for work on this section of the river, in accordance with the general plan already submitted by me (see House Ex. Doc. No. 92, Forty-sixth Congress, third session):

This work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans. Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

Amount appropriated by act approved March 3, 1881	$35,000 00
July 1, 1881, amount available	35,000 00
Amount (estimated) required for completion of existing project	3,750,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	800,000 00

IMPROVEMENTS ON THE MISSOURI RIVER.

The general plan of operations outlined in my last annual report was substantially adhered to, consequently the work done during the year has been small. The appropriations were individually very limited, and in order to effect with them the greatest possible good, it was deemed

best to expend them nearly, if not entirely, on works of channel contraction.

The spring of the year, after the breaking up of the ice, is the most favorable time for this sort of work, as there is then in prospect the long period of high-water, due to the spring and summer floods.

During this period the amount of sediment carried is at its maximum, hence the effects of silt-catching devices for building up new shore lines, by inducing deposit from the river, will then be the greatest.

With this object in view no work was done in the season of 1880, except such as seemed absolutely essential, and it was intended to devote the winter season to the procuring the needful plant, and to completing all preparations for beginning work early in the spring.

Could this plan have been carried out there is not the slightest doubt that very marked and valuable results would have been obtained, but the combination of untoward circumstances which actually obtained, defeated in a great measure the fulfillment of my expectations.

The winter was long and of unprecedented severity, rendering outdoor work almost impossible, while the blockading of the railroads by the heavy snow cut off all communication for weeks at a time.

When the ice broke up it was with extraordinary violence, doing great damage to the works, and this break-up was followed by a series of excessive floods which converted nearly the whole valley of the Missouri into a lake extending from bluff to bluff, and were accompanied by great and general destruction of property of all kinds. These floods put a stop to all work, and nothing could be done until the river had subsided and the bottoms had again become passable.

When our preparations shall have been finally completed, the time for this sort of work will be past, so that we shall have to wait for the coming spring, to give us another opportunity, work contemplated during the present season being mainly that deemed absolutely necessary for the preservation of existing works.

The combined effect of the ice and the floods was to seriously damage much of the work. Much of it had been left in an unfinished state for lack of funds, and this portion was generally greatly damaged, or totally destroyed, as was also a good deal of the earlier work, done before our present knowledge had been developed by experience. The more recent work, where finished, stood perfectly, showing that the system pursued is correct and efficient, and will give all the results anticipated, when the means are provided for its proper application and completion.

The destruction and damage caused by the floods and ice, together with the great changes throughout the course of the river, which have been thereby inaugurated, have rendered necessary a general revision of plans and estimates. The probability of this step becoming necessary has been recognized since the inception of the works, and has been alluded to in every report I have written, and if the present wasteful system of making small appropriations annually, without any regard to the estimates, and recommendations, or to the obvious requirements of the work, is adhered to, there is no telling how soon a further extension of the estimates may become necessary, nor how much the desired improvements will ultimately cost. It would be far better policy to undertake with adequate funds the general improvement of the river, by which the whole valley would be benefited, and a good navigation assured.

This course would, in the long run, be much more economical both of money and time, and would give tangible results at a very moderate cost. This whole subject was so fully discussed in my report on the

general improvement of the river, published last winter as House Ex. Doc. No. 92, Forty-sixth Congress, third session, that no further reference thereto seems necessary here; it is only needful to add, that the experience of this year confirms fully all the views therein expressed.

The special methods experimented on during the year pertain in revetment work, mainly to the very promising system of continuous mattresses having a wire net as a foundation, and to give adequate strength, the net being filled, or thatched with brush, in divers combinations, so as to afford a maximum of bank protection, with a minimum expenditure of material. This subject will be further studied during the present season. The value of wire screens as silt catchers has been fully established, and to enable them to be manufacturd with economy and dispatch, a great number of machines have been devised, and some have already been constructed, and tried.

The question of the proper manner of supporting these screens has also been the matter of experiment, piles, tripods, buoys, and other devices having been tried.

Piles have given the best result so far, and have rendered necessary the construction of special machines to sink them with a water jet. Further study will be given to this subject during the coming season.

Additional experiments were made in hydraulic grading, and the results were so encouraging as to warrant the further development of this system, by the use of more powerful apparatus.

It was abundantly shown this spring that a flat graded bank, not steeper than $2\frac{1}{2}$ horizontal to 1 vertical, is absolutely necessary to resist the ice.

No constructions, however solid, will suffice; for the heavy stone revetments constructed at various points along the river, mainly by the railroad companies, suffered quite as much damage as the lighter works put in by the government. This will require an immense amount of grading, and renders the subject of the hydraulic method one of great interest.

The assistants in local charge of works have displayed zeal and energy in the prosecution of the duties assigned them, often under very difficult and discouraging circumstances.

S 17.

PRELIMINARY REPORT UPON THE IMPROVEMENT OF THE NAVIGATION OF THE MISSOURI RIVER.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 2, 1881.

GENERAL: As stated in my annual report for 1880, I have for some time been engaged on the study of the maps and other information furnished by the survey of the Missouri River, and also of the physical data collected at various points along the stream, with the intention of submitting a report on the subject and proposing a plan for the thorough improvement of the river. Owing to the lack of certain data, which had to be supplied, and to other causes, the presentation of this report has been delayed, and even now the mass of information collected has not been put in proper shape for general study. Nevertheless, as my own ideas are sufficiently settled to allow me to point out the principles upon

which I consider the proposed improvements should be based, as well as its general scope, and also to give an approximate estimate of its probable cost, I have thought it best to present a preliminary report on the subject, which is one of great interest in this neighborhood, leaving the data upon which my opinions are based to be presented more at length at some future time.

The importance of the subject can hardly be overestimated, as this river is the longest of any in the United States, and is, with the exception of the Ohio, the largest tributary of the Mississippi. Its channel length from its sources in the Rocky Mountains to its junction with the Mississippi near Saint Louis is probably something over 3,000 miles, and it brings forward the drainage of an area of 572,672 square miles. It is navigable for nearly its whole length, for the portion above the Great Falls, near Fort Benton, is already provided with several small steamers. Its tributaries, though often of great length, are not of great size, and are rarely navigable in their present condition.

The country through which the Missouri flows is mostly one of small rain-fall, so that its really large discharge is due to the great area of its drainage basin and the mountain snows and ice near its headwaters. Its most salient and striking features are the remarkable impetuosity of its current, and its slope, which is considerable for so large a stream. The rapidity of the current and the general instability of the banks and bed give rise to the excessive turbidity of its waters, which have earned for it the title of the "Big Muddy." It is, in fact, the greatest silt-carrier in the country, and the enormous mass of sediment which it brings forward forms the great bulk of that received by the Mississippi from its tributaries. Its influence upon the main river is most marked; indeed it is its prototype in its main physical features, and, from the navigation point of view, at least, it may be said to have a marked controlling effect upon the main trunk stream. The subject of its improvement, therefore, is not only of local interest, but is of the greatest general importance now that the improvement of the Mississippi is receiving serious consideration.

The portion of the river to which this report is confined is 781 miles in length, and extends from Sioux City to the mouth. The general direction of the valley from Sioux City to Kansas City, 406 miles, is slightly east of south; for the remaining 375 miles it is nearly east and west.

For the period covered by possible navigation—that is, the period when the river is unobstructed by ice—the range of water surface varies from 16 to 20 feet at different localities and in different years. During the winter the river may fall 3 or 4 feet lower, and unusual floods may increase the height by an equal amount or even more, as in the great flood of 1844. This latter flood, however, was entirely abnormal and due to causes of which we have at present no definite knowledge.

The amount of water discharged is, however, subject to a much greater variation than this range of surface elevation would imply. Our gauging observations at Saint Charles, near the mouth of the river, showed a variation in 1879 from 26,446 to 298,537 cubic feet per second for a range of $17\frac{1}{3}$ feet on the gauge, or a low-water volume about one-eleventh that of high-water. From these observations it was further inferred that the ordinary range of the gauge would give volumes of about 15,000 and 430,000 cubic feet per second for low and high water, respectively. This would make the low-water volume about one-twenty-eighth that of the high. At Sioux City, 781 miles above, the variation in discharge was about the same, while the total discharge in passing over this

distance was increased about 100,000 cubic feet per second in flood and 8,000 cubic feet at low-water.

The regular floods are two in number, and usually occur in April and in June. The first is extremely violent and of short duration, rarely lasting over a week or ten days; it seems to come largely from the upper river. The June rise, although generally higher, is of longer duration, being influenced by local rains and the general saturation of the soil. It is followed by a steady fall, which continues with considerable regularity till the freezing weather closes the small affluents as well as the upper river; then a sudden fall of 3 or 4 feet takes place, and the river reaches its winter level. There are occasional small rises of short duration besides those mentioned; one, especially, usually occurs late in the fall, but the two first mentioned are from all points of view the most important. The rate of travel of the crest of these floods is, on an average, about 6 miles per hour. The April rise is generally the most destructive, for it shows, for a time at least, a tendency to follow the channels developed during the low-water season preceding, and, as a consequence, the banks are attacked with extreme violence. When the June rise comes the bed is in a measure shaped for its reception by the preceding flood, and the water passes off with somewhat less destructive results. Both, however, have sufficient power to produce tremendous effects and bring about the most astonishing changes.

The main valley of the river consists of a great rock trough, from 1½ to 17 miles in width, cut down from the general level of the country to a depth considerably below the present level of the valley. The rocky banks form bluffs along the stream, and the bed is also of rock. This great trough seems to have been filled at one time with the glacial drift deposits, which also cover the adjacent country, and subsequently in part cleared out by the great river that probably occupied it in early post-glacial times. The drift deposits seem everywhere pretty well sorted out; bowlders are generally found next the rock, and deposits of varying degrees of coarseness above. The main feature is the great preponderance of extremely fine sand, which, with the addition of a very small amount of alumina, forms an extremely tenacious clay, locally known as "gumbo," and which is met with everywhere, and is formed in the bed of the stream wherever the current is unusually slackened. Large beds or pockets of very coarse gravel or pebbles are also met with in borings at different depths below the surface. They are usually water-worn fragments of quartz, mostly red and yellow jasper. The general absence of the large, high, and well-defined terraces, which are usually found in valleys of this description, and the general prevalence in the surface soil of the very fine sand before alluded to, leads to the inference that the river, within comparatively recent times, has scoured over the greater part of the area embraced between the limiting bluffs, at least in the narrower portions of the valley. The valley below Saint Joseph averages about 2½ miles in width; above that point it is wider, reaching 17 miles in the neighborhood of Sioux City.

The general depth of the rock bed below the surface of the valley varies from 70 to over 100 feet wherever borings have been made. The piers of the numerous bridges erected are founded on rock in most cases, and the borings which have been made at these and other proposed bridge-sites, together with work done under my own direction, enable me to assert with considerable confidence that no rock in place will be met with at a higher level. At the few places where it is found in the bed of the present stream spurs or ledges projecting from the main bluffs are the cause, while the general depth of the rock valley beyond these ledges

is unchanged. Moreover, if at any place rock did occur at a higher elevation within the bed of the stream, it would be indicated by local increase of slope, but such is nowhere the case, except at the points alluded to. As I am of the opinion that at these few points the obstructions can readily be flanked, I think it perfectly safe to count on any amount of depth of channel deemed necessary within the limits stated. At some points on the river layers of bowlders of considerable size form the bed of the stream in flood, and have been mistaken for rock in place. At Saint Charles the piers of the bridge pass through a layer of this description, but the bed rock was found below the bowlders and at the usual level.

As may readily be inferred from a comparison of the volume of discharge with the variation in level of the water surface, the velocity of the current is very great. At low-water the average is from 2 to 3 miles per hour, while in floods it amounts to 10 miles per hour or more. Owing to this cause, and also to the large amount of very light material in the bed and banks, the amount of bank erosion and scour and fill of the bed is very great and very rapid. Bank erosion to the extent of 2,000 feet per annum, over long distances, has been noted, and to a greater or less extent it is constantly going on, even during low stages. The enormous amount of material thus precipitated into the river, together with that scoured from the bed, causes the formation of innumerable bars, which, even at high-water, obstruct navigation. These bars are constantly in motion, their position and shape changing from day to day. The channels through them are also changing both in depth and location, rendering navigation correspondingly uncertain. Owing to the incessant bank erosion the river is steadily increasing the width between high banks, as the bars which are formed opposite caving shores take time to build up to the general level, and are meanwhile liable to be themselves attacked and swept away. The erosion which usually occurs on the upper sides of points, causes these points to move bodily down stream. Where the erosion is more rapid than the bar growth below, the point disappears, and the river's course is detrimentally straightened. Where a point or projecting neck is attacked on both sides, a cut-off is soon formed, which also acts detrimentally by increasing the local slopes and inaugurating other destructive changes. The caving of the banks precipitates into the river countless trees, which form the snags that constitute, in the strong current, most serious dangers to navigation, and also assist in impeding the free flow of the stream. The slopes vary from point to point, being, as usual, greatest on the crossings of the bars, and less in the pools above them. The general slope of the river, however, as determined by simultaneous gauge readings, is remarkably uniform. It averages 0.88′ to the mile both at high and low water.

Owing to the great movement of sand, when the current is strong, the bars are rapidly built up as the river rises, and although elsewhere the river follows the general law of scouring its bed at high-water, and filling it at low, yet at these places of local engorgement the depth over the bars, as also in the channels leading through them, is much less than the low-water depth plus the rise of the water surface. The actual navigable depth of the river varies from about 3 feet at low-water to 9 feet at high-water, though, of course, at the latter stage the channels are wider and the number of very shoal bars is reduced.

The amount of sediment carried by the river is very great, and it is only when ice begins to form that the water becomes comparatively clear. At all other stages the water is muddy, the amount of sediment carried increasing with the volume of discharge. From observations

carefully made at Saint Charles the sediment carried in suspension past that station for the year 1879 is shown to have amounted to 5,508,229,008 cubic feet, the water discharge for the same period being 2,335,143,946,400 cubic feet; the proportion by volume is 1 to 424, and by weight 1 to 265. For the single day, July 4, 1879, the amount of sediment thus transported would have covered a square mile to a depth of 4.041 feet, and during the entire year an amount of sediment passed Saint Charles sufficient to have covered a square mile to a depth of 197.58 feet. The samples of water that were analyzed were taken at the surface, the mid-depth, and at one foot from the bottom, and the arithmetical mean was taken for the mean result. The true amount would therefore of course be greater. Moreover the last foot of depth was not considered, but the increase in amount of sediment from surface to bottom was such as to lead to the inference that the amount moving in this lowest stratum might be fully equal to the amount actually collected. The observations also took no note of the material in motion on the bottom, known to be great in amount but never yet successfully measured. For these reasons it seems probable that the amounts above given would have to be at least doubled to get a just idea of the amount of solid matter brought into the Mississippi by the Missouri. On this supposition the total amount per annum would be 11,000,000,000 cubic feet, enough to cover a square mile to a depth of 400 feet.

An examination of the sediment samples collected shows that only the finer materials are carried in suspension within the limits covered by the observations; the coarser particles of sand are either rolled along the bottom or carried intermittently in close proximity to it. As might be anticipated, the water is so heavily charged with sediment that decrease in velocity is immediately followed by a considerable deposit, but the converse of scour following an increase of velocity, although apparent, is not so well marked nor so extensive. This is explained by the fact that the largest portion of the suspended sediment is undoubtedly due to the caving of the banks, in which process a much larger amount of material is thrown into the stream than is due to actual erosion. By this latter action the toe of the bank is undermined, and the upper portion, being unsupported, falls in, when the lighter materials of which it is composed are carried off by the water in a state of suspension, the heavier materials remaining on the bottom. The increase of velocity due to concentration, however brought about, sets up a very heavy scour on the bottom, the bed rapidly deepens, and the excavated material is carried away, the greater portion being probably dropped as soon as the local concentration of volume is at an end.

The regular formation and movement of sand waves is not conspicuous except at low stages; during floods the velocity of the current is so great, and the bed so yielding that the materials composing it seem to be moved bodily in mass as if the bed were in a semi-fluid condition.

The difficulties of navigation are mainly due to the small depth on the bars, a description of which is essential to a proper understanding of the subject.

Wherever certain limits of width are exceeded the river very generally shows two narrow pools or channels of deep water, one adjacent to each bank. Between these lies a bar, the depth of water on which is much less than it is in either pool. The pools are narrow and deep, closed at each end, and so located that the head of any one lies opposite a point intermediate between the head and foot of the pool adjacent to the opposite shore. It is generally impossible to pass from one pool to the next succeeding one on the same side of the river, so that in practical

navigation boats are obliged to cross the intermediate bar to pass from the pool on one side to the one opposite, then back to the next one, and so on. The bars between the pools are often very extensive. They lie diagonally across the stream, alternating from bank to bank, and are often several miles in length. They are intersected by numerous channels of comparatively small depth. At low-water large portions of these bars are laid bare, and under favorable circumstances a growth of willows will start on them, and they then become the nuclei of islands. After the willows get a good foothold the sediment arrested in floods gradually builds up the surface till it is too high for the growth of willows; cottonwoods then succeed, and finally other trees gain a footing, and the island is raised to the general level of the bottoms. In spite of this transformation the connection of the islands with the bar systems remains sufficiently obvious when long reaches of the river are considered.

The general dimensions of the bars depend mainly upon the width of the river. Their exterior boundaries follow closely the outlines of the main shores, being separated from them by the water in the pools. In the space between the foot of one pool and the head of the next adjacent one, the bar joins the shore line, and its general direction then changing, it trends towards the opposite shore, which it reaches in the space between two adjacent pools on that side. When the general direction of the river is a curved line, the bars follow the curves closely, the deep pools lying next the concave shores. The general depth on the bars varies also with the width. Where this latter is but little in excess of that which does not allow a bar to form, the middle bar may be deeply submerged, and only indicated on a cross-section of the stream by a slight rise of the bottom near the middle width. Again, where the width is great, some portions, viz, islands, remain dry even at high stages. While the general position of the bars remains constant, their shape, the depth over them, and the position and depth of the channels through them, are constantly varying. The pools also are, to a considerable extent, influenced by these changes, portions being filled up or excavated from year to year, as the distribution of the flow of water over the bar varies. The side of the bar next the down-stream pool is usually quite steep, the depth on the bar crest is less than at other points, and the slope which connects it with the up-stream pool is very gradual. These bars, extending, as they do, entirely across the stream, act like low or partly submerged dams, and the ponding up of the water due to this cause gives rise to the pools in which the slope is much below the average, while on the crossing from one pool to another it is much above the average. Even at high stages this difference of slope is very conspicuous. In passing from one pool to another the water begins to pour over the bar at the head of the down-stream pool. After reaching the pool the water flows along the lower edge of the bar, receiving as it goes additional supplies from the sheet of water flowing over the bar crest. The volume of water in the lower pool, therefore, increases from its head to a point about opposite the head of the next pool of the series. When this point is reached the second pool begins to discharge into the third precisely as the first had discharged into the second, and its volume of water diminishes throughout the remainder of its length. Each pool therefore shoals towards its head and foot, and its width decreases also, though in a smaller proportion. The result of this double flow, along the axis of the pool and across the crest of the bar, is to force the body of water in the pool against the bank, while eddies are generated, often of great size. Under these circumstances there is always a tendency to erode

the banks, and in direct proportion to the amount of water coming over the crest of the bar. Where a channel is cut through the crest this action is very powerful, and erosion is generally initiated at such points. After an indentation is once made in the outline of the bank the eddy generated thereby extends the cutting down-stream for long distances, and where the shore line is curved the width of the swath thus cut out increases as it progresses down stream. As the bank recedes the crest of the bar advances correspondingly, its lower face being no longer swept clean by the current in the pool, till the original cross-section of the latter is reestablished and the advance of the bar is stopped. In my opinion the caving of banks is almost, if not entirely, due to this action. Where the current flows parallel to the shore without cross-currents or eddies there seems to be but little, if any, erosion.

At many points along the river are found reaches of moderate length where the width is too small to allow the formation of a middle bar. At these places, often very narrow, the whole volume of water, even in floods, flows in a concentrated mass, the direction of the current being parallel to the banks. From the date of the earliest land surveys (1817) these places seemed to have remained almost unchanged, there having been very little erosion. At these places, as the river rises, the bed regularly deepens, and it fills up again as the river falls, leaving the relative section unchanged from year to year, while the depth, even at low-water, is much greater than the average. The slope is usually less than the mean slope of the river. The pools also are of this same general type, but more exaggerated and modified by the peculiar manner of their formation. If the bar crest above them were dry, and all the water entered them through one channel, they would be entirely similar.

During flood stages the general movement of sand is in a measure arrested on the shoals, and, as a consequence, the low-water channels leading through them are silted up, while new ones are developed which accommodate the high-water flow. As the river falls these latter channels are silted up, and the water ponds up behind the bar until sufficient head is attained to force a breach through the crest at one or several points. These breaches are the low-water channels, and through them boats have to pass on their way from one pool to another. The depth in these channels depends mainly on the number; where there are many, and there is also a considerable flow over the crest of the bar, the depth is smallest and navigation the most impeded; where the flow is more concentrated, the depth is proportionately increased.

During the course of the low-water season the main channel keeps shifting from one subsidiary channel to another; these changes of location are often very great, and the uncertainty thereon attendant forms one of the greatest drawbacks to navigation. The high-water channels, before alluded to, are, in the Missouri, of the same general character as those of low-water, but they rarely coincide with them. They are less tortuous as a rule, but not of much greater depth, and they are liable to the same rapid changes of location.

The main points, to which attention should be directed, are the constantly varying slopes, cross-sectional areas, and velocities. At the narrow reaches and in the pools we have a small slope and small cross-sectional area, especially characterized by great depth, small width, and high velocity; while on the shoals we have an excessive slope, a very large area of cross-section, with excessive width, very small depth, and low velocity. The amount of water passing is the same in both cases, but the ratio of frictional surface to area of water-way is small in one case and large in the other. The increased slope observable in the last

case is its direct and necessary consequence, as the additional head thus created alone enables the water, when flowing through the larger cross-section, to overcome the added resistance due to the increase of frictional surface. It is evident from this fact that the contracted section is more favorable for the discharge of a given volume of water than the other, as the mean velocity is greater while the slope is much less.

Now it must certainly be admitted that, at any point and at any time, a river adjusts itself to the various conditions imposed upon it by the bed through which it flows. As the volume of discharge increases, the surface of the water rises, the river spreads out laterally, and thus obtains greater area of cross-section, while the velocity of the current increases. But on rivers flowing through alluvial deposits a further change takes place, for, the bed being of a yielding character, the increased velocity of the current is sufficient to set up scour, which is greater or less according to the increase of velocity and the relative stability of the bed. At the concentrated sections, where a great increase of velocity takes place, this scour is large; whereas at the wide, shallow sections, where the increase of velocity is small, the bed not only does not scour, but actually fills up, as the material scoured out of the deep pools is arrested there by the decreased velocity of the current. When the river falls, the velocity of the current over the shoals is locally increased, while that in the deep pools is slackened. Local scour then sets up on the bars, and the materials thus removed are dropped in the pools, where the current is no longer strong enough to move them, and as a consequence the bed of the pools rises. It is the same with the materials precipitated into the river by the caving of banks; the lighter materials are swept off in suspension, while the heavier sand is carried through the pools by the strong current there prevailing, and dropped on the shoals below, where the velocity of the current is less.

Such, in very general terms, is the nature of the changes that take place, and it being obvious that the difficulties of navigation arise from lack of sufficient scouring power at special localities, all systems of channel improvement seek to remedy this difficulty by concentrating the flow of the water at such localities. The method usually followed seeks to concentrate the whole low-water discharge and a portion of that pertaining to higher stages into one channel of such dimensions as will best subserve the special object aimed at. This system generally commends itself on grounds of economy, the extent of the works required being, as a rule, small. It is, however, open to many objections. In the first place, its scope is limited, only a moderate improvement being possible. In the second place, it is uncertain, as the amount of the deposit of floods varies from year to year and may at times be in excess of the capacity of the works of improvement to remove rapidly after they begin to act. In the third place, it is not necessarily permanent, as the high river over which it has no control may, by abrasion of banks and other means, effect such changes as to render the works useless, or even cause them to become actual obstructions. All these difficulties are enhanced when the river is large and its regimen very unstable, and, on the Missouri, this cause alone would, in my opinion, render such a system entirely impracticable. The only system which promises results of permanent value here is one which will control the river at high as well as at low stages. The points which such a system should seek to obtain, at least approximately, are, at any stage, equality of cross-section both in width and depth, uniformity of slope and in consequence uniformity of velocity, while the channel at all stages shall be permanent in location. The width should be such that at high stages the bed will be scoured to

the greatest attainable depth, while at low-water the greatest depth compatible with navigable width will be retained. The slope should be as small as it is possible to obtain within the limits of the present banks. The volume of discharge, the attainable slope, and the depth to unyielding strata, in this case bed-rock, will alone limit the scope of such an improvement. It would not, of course, be possible to bring the whole river to the dimensions of the pools, as the small slopes which exist there could not be obtained, but a mean result corresponding nearly to the average slope of the river is possible. After a careful study of all the data collected, I am of the opinion that for the portion of the Missouri River under consideration, about 800 miles in length, and extending from the mouth to Sioux City, Iowa, a uniform navigable depth of 12 feet at lowest stages can be guaranteed. This depth would allow boats to load to 8 or 9 feet and run with perfect freedom, while at higher stages the depth would of course be much greater. To effect this improvement the high-water width of the river must be decreased and be brought within certain limits which increase with the increased volume as we proceed down stream, while the general direction given the rectified channel must be such as will insure the smallest slope attainable consistent with other conditions. Approximately these high-water widths are as follows:

	Feet.
From Sioux City to mouth of Platte	820
From mouth of Platte to mouth of Kaw	960
From mouth of Kaw to mouth of Gasconade	1,160
From mouth of Gasconade to the Mississippi	1,240

At low-water these widths become, respectively, 650 feet, 820 feet, 1,020 feet, 1,100 feet, the low-water and high-water lines being connected by slopes flat enough to be permanent. The increase of width at high-water is merely such as, with the scour on the bottom, will insure the requisite area for the flood discharge. The dimensions of the high-water section are therefore regulated by those of the low-water section, which is designed to insure a definite depth of 12 feet at lowest stages. The scour which it is expected to induce by this contraction is under, rather than above, what commonly occurs at all the deep sections along the river, and is thought to be readily attainable. When a channel of the dimensions indicated has once been cut through the shoals, any impediment to navigation due to these latter will of course disappear, and they cannot reform because, the velocity being uniform, there can be no tendency to deposit at any one place more than at another. As the river falls from high to low water the bed will be uniformly silted up from one end of the river to the other, but not to such an extent as to diminish the expected low-water depth.

The range of elevation of water surface from high to low stages will of course be somewhat increased, but the actual elevation of floods will probably be lower, as there will be no local engorgements of sand as at the present shoals to raise the surface of the water and diminish the freedom of flow. The whole of the river bottom will therefore be benefited in this way, in addition to the security conferred by the works against destructive bank erosion.

To accomplish these results it is proposed to employ the methods already successfully applied for some years past at various points along the river, and which have been described at length in my annual reports. By the use of suitable devices the velocity of the current is checked where desired, so as to induce a deposit of the sediment which it carries. By taking advantage of the season of floods, when the amount of material moving is large, deposits of very great extent can be readily induced.

The object is to so locate these deposits that they shall occupy those portions of the river bed that it is designed to abandon, leaving unobstructed those portions to which it is desirable that the channel shall be directed. The river is thus expected to build up the new banks and excavate the new channel. By following up the action it is anticipated that after one or two seasons the rectification will be completed and the new banks will be raised sufficiently high to support a growth of vegetation. They, and all other banks exposed to erosion, will then be protected by light mattress revetments. The work so far done under this permeable system of improvement, although largely experimental, has given very encouraging results, and the cost of the silt-catching devices, revetments, &c., has been brought to very low figures, so that in the case of a river which like the Missouri is very heavily charged with sediment, works may safely be projected to accomplish results of a scope and magnitude utterly unattainable by any other methods.

Work already done furnishes me the means of approximately estimating the cost of this improvement, which, if carried out on a large scale, and with liberal appropriations, will probably not exceed $10,000 per mile. This would put the cost for the whole 800 miles under consideration at $8,000,000, and from Kansas City to the mouth of the river at $3,750,000. If this work is undertaken it will, in my opinion, be absolutely necessary to confine the work at any time to such a length of river as will allow of the rectification being entirely completed with the sum appropriated. In other words, the money should be allotted to the improvement of a certain reach of the river, and the engineer in charge should be left entirely untrammeled to decide how and where within that reach the money should be expended. In order to economize in the outlay for plant, these reaches should be in lengths of not less than 50 nor more than 100 miles, and the work should be continuous—that is to say, as soon as one reach is finished the next in order should be taken up. For many reasons it would be advisable to begin at the mouth of the river and work up stream, making the improvement continuous and complete as it progresses. It must be distinctly understood that the estimates submitted are based upon the supposition that work will be carried on in the manner indicated; if the money is to be frittered away at isolated points, and the improvement carried on in a disjointed and arbitrary manner, no estimate of the ultimate cost is possible, but it would probably be three or four times greater than the figures given here. In work of this kind it is essential, both for the sake of economy and to insure ultimate success, that the money shall be available when work can be done to best advantage, and in such amounts that each separate piece of work may be pushed at once to completion. Anything left unfinished is pretty certain to be destroyed, and the ultimate cost will thus be enhanced, not to mention the trouble and expense attendant on the frequent revision of plans thus rendered necessary.

The benefits attendant on such an improvement can hardly be overestimated. With a guarantee that at lowest navigable stages a safe and permanent channel, having nowhere a less depth than 12 feet, will be available, boats and barges as large as any now used on the Lower Mississippi could be built and safely navigated. They could also be provided with heavy power and staunch hulls such as would be needed to cope with the strong current of the Missouri River. Snags, which now are great and ever present obstructions, would be to a great extent swept away by the deep scour of floods, and the supply of new ones would be materially reduced by the general prevention of bank erosion. The amount of sediment carried into the Mississippi would be propor-

tionately reduced by the same work, and very substantial benefit be thus indirectly received by that river. The whole valley of the Missouri is extremely fertile, and if reclaimed, as it would be by this improvement, would soon all be under cultivation, and the amount of grain which would seek the river transportation would be enormous. The estimate for the whole work thus sketched out is $8,000,000, which could, with due regard to economy, be expended at the rate of $1,000,000 per annum. At this rate the whole improvement would require eight years for completion, or from Kansas City to the mouth four years, with proportionate increase of time if the annual appropriations should be smaller than here indicated.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

S 18.

SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY, IOWA AND TO FORT BENTON, MONTANA.

During the past season work was mainly confined to the reduction of notes of the field work already accomplished, and to the preparation of maps.

Detached parties were sent out to collect missing topography, and a check level line was run from Sioux City down and nearly completed. This will finish the field work to Sioux City. The large sheets of the survey are about finished in pencil, and are now being inked; their reduction to a scale suitable for publication is in progress and will be completed during the coming season.

As soon as the field parties can be reorganized, and a small steamer suitable for quartering and transporting them can be procured, work will be resumed.

It is intended this season to push the survey to Fort Randall, Dak., 250 miles above Sioux City, Iowa, the present terminus of the work.

The cost of the extension of the survey to Fort Benton is estimated at $105,000, of which $50,000 can be expended in the next fiscal year.

A preliminary report upon the general improvement of the Missouri River from Sioux City to its mouth, with plan and estimates, was prepared from the data collected by this survey, and was submitted to you under date of February 2, 1881, and was printed as House Ex. Doc. No. 92, Forty-sixth Congress, third session.

The work of the survey was carried on, as during the previous season, under the direction of Assistant D. W. Wellman.

Money statement.

July 1, 1880, amount available	$30,151 82	
Amount appropriated by act approved March 3, 1881	30,000 00	
		$60,151 82
Amount allotted for protecting work done on the Missouri River at or near Sioux City, Iowa (act approved June 14, 1880)	4,000 00	
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	22,360 27	
		26,360 27
July 1, 1881, amount available		33,791 05
Amount (estimated) required for completion of existing project		105,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

S 19.

IMPROVEMENT OF GASCONADE RIVER, MISSOURI.

Work on this river was begun October 22, 1880, in accordance with the general plan submitted under date of February 11, 1880, and with the act of Congress making appropriation for this improvement, which specially limited its scope to the removal of snags from the river.

The river being dead low, the snagging party in charge of Assistant Thomas T. Johnston, were enabled to work from the banks of the stream with rapidity and efficiency. The work was prematurely terminated December 31, 1880, by the freezing of the river, and has not yet been resumed. As soon as the river falls to the proper stage two parties will be set at work and the work pushed as far as the funds available will allow. The work already done is reported to have been of marked benefit to navigation.

This work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans. Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, was $1,218,122.44.

Money statement.

July 1, 1880, amount available	$5,000 00	
Amount received from sales of fuel to officers	39 37	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$15,039 37
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		3,969 87
July 1, 1881, amount available		11,069 50
Amount (estimated) required for completion of existing project		35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		35,000 00

S 20.

IMPROVEMENT OF ARKANSAS RIVER AT PINE BLUFF, ARKANSAS.

A party was organized for commencing work at this point in November, 1880, Assistant W. H. Byram being in charge. Plans had been prepared for prosecuting the work, and the collection of plant was in progress, when, on February 1, 1881, the charge of the work was by your order turned over to Capt. Thomas H. Handbury, Corps of Engineers, United States Army.

S 21.

IMPROVEMENT OF ARKANSAS RIVER BETWEEN FORT SMITH, ARKANSAS, AND WICHITA, KANSAS.

During the fall of 1880 a party under the charge of Assistant John H. Curtis was sent to Wichita, Kans., to prepare the necessary plant for beginning work at that point upon the Arkansas River.

The extremely small depth of water available for navigation in that

part of the stream, about 6 inches, seemed to render it necessary to do the work required in removing snags and other obstructions by means of parties working from the banks of the river.

As soon as the party could be got ready work was begun, and had progressed as far as Oxford, Kans., when the river became closed by ice, and operations were suspended.

Before they could be resumed orders were received to turn the work over to Capt. Thomas H. Handbury, Corps of Engineers, United States Army, which was done February 1, 1881.

S 22.

SURVEY OF MISSOURI RIVER AT BOONVILLE, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 5, 1881.

GENERAL: I beg leave to submit the following report on the condition of the Missouri River at Boonville, Mo., with plan and estimated cost of the proposed improvement.

From an inspection of the accompanying map, which shows the shore lines, &c., of surveys made in 1878, 1879, and in 1880, it will be seen that this portion of the river is of excessive width, and being cut up by islands, it presents several channels, any of which may become at times the main channel of the river.

The old land office maps of this vicinity show that the erosion of banks and general widening of the river have been general throughout the reach. Just above Boonville the left bank has been greatly abraded. The site of the town of Franklin, opposite Boonville, has been entirely washed away, and Gardner's Island has been moved to the north as the left bank receded.

Below Boonville the left bank has also been severely eroded, even in recent years, with a resulting extension of the left bank of Franklin Island.

The present condition of affairs is shown by our maps, the old shore lines of land surveys being indicated by dotted lines.

Before the construction of the railroad bridge in 1873 there was a good deal of water flowed to the left of Gardner's Island, and the harbor of Boonville was nearly destroyed at low-water.

In constructing the approaches to the bridge this chute was closed by an earthen dike, with very beneficial results, for a time at least. Subsequently, however, heavy erosion set in just below the bridge, and extended down through Franklin Bend. This erosion still continues, and as a consequence the bar on the head of Franklin Island has extended up stream till at low-water it actually crosses the line of the bridge, rendering it well-nigh impassable. There has also been an enlargement of the chute to the right of Franklin Island, with further detriment to the navigable depth in the main channel. As matters now stand, boats coming to Boonville from below, at low-water, are obliged to go up through the north draw-opening of the bridge, then run up around the head of the bar, and following down the right bank pass through the south draw-opening to reach the town landing.

There is nothing to check further detrimental changes in the same

direction, and, if it goes on much longer, the draw-openings will be entirely closed, and the bridge will become impassable.

It is thought that any improvement designed to remedy the existing state of affairs should contemplate the complete rectification of the river for a distance of at least 9 miles, the limits of the accompanying map, and this rectification should conform to the general plan laid down in my recent report on the improvement of the whole river.

It will be observed that for about a mile above the bridge, the river is contracted to a width of 1,300 feet, and the whole volume of water, even in floods, passes through this section. The width and slope through this reach correspond fairly with those assumed on theoretical grounds for this portion of the river, and as soundings and borings show that the high-water section can be and in fact is obtained by scour to bed-rock, it is proposed to adopt the width here found for the improvement contemplated. This should give at low-water a uniform channel depth of about 12 feet. The low-water banks will be about 1,100 feet apart, and connected with those of high-water by slopes flat enough to insure their stability.

In carrying out this plan it is proposed to develop the proposed shore line indicated on the map, by obstructing the current at high stages by wire screens or nets suspended from piles, or other equivalent device, and located on or near the proposed shore lines. These screens soon fill up with floating brush and all sorts of vegetable *débris*, and oppose such a check to the current that the sediment which is being transported by the water is dropped behind the screens, and under favorable circumstances will soon silt up the whole area protected by the screens. After one or two floods, it is expected that these portions of the bed will be entirely reclaimed to above the line of low-water. By means of sand-fences of brush, the sands drifting before the wind are arrested, and by this means the level of the new shores will be raised till they are capable of supporting a growth of vegetation, after which they can be left to themselves, as they will soon attain the level of the main banks. When the new shore lines are once established, they and all other banks exposed to erosion must be protected by light mattress revetments.

The methods here described have all been tried with success, and I do not think there is a shadow of a doubt of obtaining the desired results provided funds are allotted as asked for. If this is not done, the work put in during one season is necessarily incomplete, and is liable to be destroyed before another appropriation is available. Changes are also sure to occur, which would have an important bearing on the ultimate success of the work, and means should be available to meet them promptly, otherwise the entire plan may be vitiated, and all the work completed may be rendered useless. To insure success the work should be promptly pushed to completion, and to do this the whole amount of the estimate should be available when the work is commenced.

For the construction of the works here indicated, including the cost of plant, superintendence, and general contingencies, I estimate that the sum of $110,000 will be required, which can advantageously be expended in one season.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

MAP
OF THE
MISSOURI RIVER
in the vicinity of
BOONVILLE, MO.

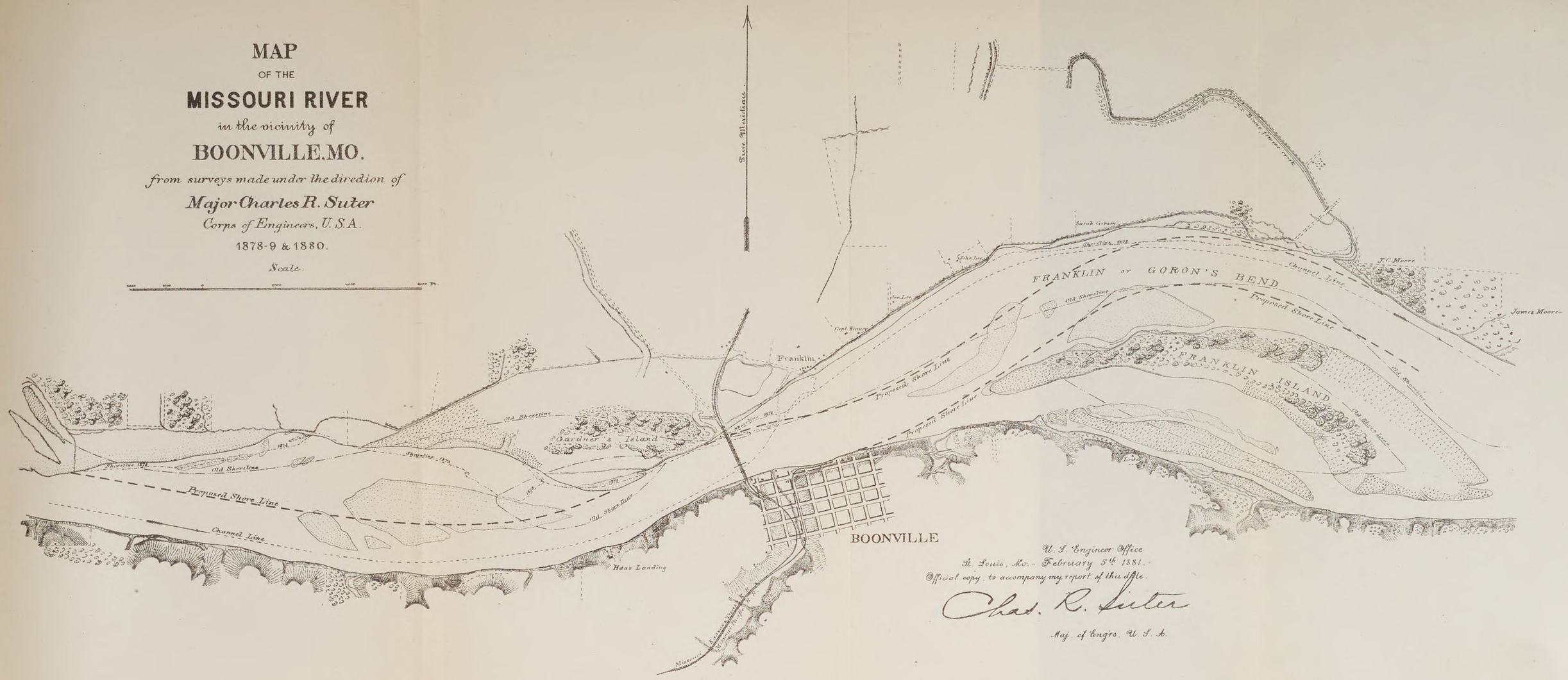
from surveys made under the direction of

Major Charles R. Suter

Corps of Engineers, U.S.A.

1878-9 & 1880.

Scale



U. S. Engineer Office
St. Louis, Mo. – February 5th 1881.
Official copy, to accompany my report of this date.

Chas. R. Suter

Maj. of Engrs. U. S. A.

S 23.

SURVEY OF MISSOURI RIVER IN THE VICINITY OF YANKTON, DAKOTA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 5, 1881.

GENERAL: I beg leave to forward herewith a copy of a report, of Assistant Engineer T. T. Johnston, on the survey which he made under my direction of the Missouri River in the vicinity of Yankton, Dak., during the past summer. Mr. Johnston's report, with the accompanying map, fully explains the condition of affairs at this locality.

It will be seen that, owing to certain changes in the regimen of the Missouri River, a very destructive erosion is in progress along the lower portion of the town front of Yankton, involving great destruction of valuable property, and other evils, while a bar which has formed in front of the upper end of the town shuts off all access to the old steamboat landing. The town is one of great importance, and grave inconvenience will result to many interests if this state of affairs is allowed to continue.

Mr. Johnston's report shows that there would be no great difficulty in giving the river in this vicinity a stable regimen, while at the same time all the important interests would be protected. To accomplish this result the rectification of about 12 miles of river will be necessary. Upon the accompanying map I have indicated the position of the proposed high-water shore lines, which are so located as to bring the river against the bluffs at Yankton, and to throw it away from that portion of the town where erosion is to be apprehended. The proposed improvement would undoubtedly also give a good navigable depth throughout the reach. It is based upon the same general plan as that proposed for the river below Sioux City, and the same methods of construction should be employed as are there described.

The width between banks, 900 feet, may require to be reduced, but it is not thought probable that such will be the case for some time to come at least.

The cost of the proposed improvement will be at the rate of $10,000 per mile, and the total cost $120,000, which can be expended in one season.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. THOMAS T. JOHNSTON, ASSISTANT ENGINEER.

LEACHE'S MILL, MO., *November* 10, 1880.

MAJOR: I have the honor to submit the following report on the survey of the Missouri River at Yankton, Dak., * * * made by me under instructions from you, dated August 16, 1880.

YANKTON SURVEY.

A combination of lines along the course of the river, checking frequently upon each other, was made; the shore lines and general topography on the islands and sand-bars, and adjacent to the main shores, were sketched into this system of lines; connec-

tion on the north side of the river was made with the land surveys, from the official plats of which was taken the position of the bluffs where distant from the river; all angles were measured with a Heller and Brightly transit, and the lengths of all lines by the use of the stadia wires. Thirty-eight lines of cadenced soundings were made, located as shown on the accompanying map, upon which the depths are recorded. Elevations of the water surface were referred to bench marks on the shore, from which was deduced the profile on the accompanying map, distances being measured along the channel (on the map the broken line near the left bank).

The fall from △ 59 to ⊙ 33—a distance of 45,600 feet—is 12.32 feet, or 1.43 feet per mile; from ⊙ 33 to ⊙ 39_2, a distance of 12,100 feet, the fall is 1.95 feet, or 0.85 foot per mile.

The length of river surveyed was 12.3 miles nearly, the work of doing which was much interfered with by the heavy and numerous rains which fell while the work was being prosecuted. The plan of the town of Yankton was taken from a sketch held by the recorder of deeds at that place. The notes of the compass meander of the shore at and below Yankton, shown on the map, were obtained from the same source.

The accompanying map shows the result of the work, concerning which the following may be remarked by way of description. At and above Yankton the river flows between bluffs which are, at their bases, about 10,000 feet apart. These bluffs slope away from the river bottoms at a moderate general grade; they are without timber, except such brush as grows in the gulches cut through the drift (and often into the rock) by which flows away the surface water; along those parts of the bluffs at which the river has been contingent in recent times, and now is, the gravel and sand talus has been washed away, and a precipice of soft rock rises from the high-water shore line to heights varying from 50 to 150 feet. (Two specimens of this rock accompany this report.) Below the high-water shore line the rock surface curved away toward the river.

Near the head of the reach (on the left) the river comes to a rock bluff, along which it has coursed for a long time, and down which the bend above is creeping; leaving this at ⊙ 3, with a narrow strip of bottom land intervening, it again comes to the bluff about 1 mile below; here, instead of rock, the river strikes the gravel and sand talus, or terrace, as it here is, into which it is cutting; no rock is nearer, perhaps, than the high bluffs 2,000 feet back from the river. Crossing to the right the river comes to a rock-bluff point near the middle of the reach; just below where the river comes to the bluff, the rock disappears under the gravel and sand talus, now being eroded, and along which the river flows about 1 mile; but the rock remains close at hand, not farther away, perhaps, than 200 feet, until the river starts towards the left bluffs. Several years since it came to these bluffs, near the foot of Broadway, in Yankton, at which place steamboats landed. The bend above has dropped down rapidly, and has now forced the river past the corner, or point of the bluffs, on which Yankton is; and now the banks below the town are being rapidly eroded. The railroad has several times been obliged to move its tracks inland, and its shops are now threatened. The steamboat landing is now a short distance below the town, and it appears must yearly be driven farther away. Below Yankton the bluffs spread several miles apart, due to the influx on the north of the James, or Dakota River. According to Samuel Aughey's "Geology of Nebraska," it appears, the body of the river and bottom lands lie in the lower part of the Niobrara group of rock, in the lower series of Meek and Hayden's divisions of the Cretaceous period, and thus described by them: "Lead-gray calcareous marl, weathering to a yellowish or whitish chalky appearance, &c."

The bottoms are for the most part prairie lands, except where cultivated or timbered; the grass mostly blue-joint, is tall and thick; it averages, perhaps, 4 or 5 feet in height. I am informed that when cut away several times it comes up finer. Where the ground has been broken and cultivated once and then left to itself, wild sunflowers, often 15 feet high, grow up thickly; this fact holds on the high bluffs as well as on the bottoms. Timber is scarce and valuable, and is almost entirely cottonwood; several elm trees, and large willows (accidental growth) were noticed; the down-stream side of bends are always wooded more or less; and as these, or the analogue, must at some time have occupied every part of the bottoms, the latter have been wooded in times recent. Where exposed, at cutting banks, a section of the bottom lands is made up of strata of gumbo, sand, clay-like soil, and loam, more or less thick, and irregularly placed.

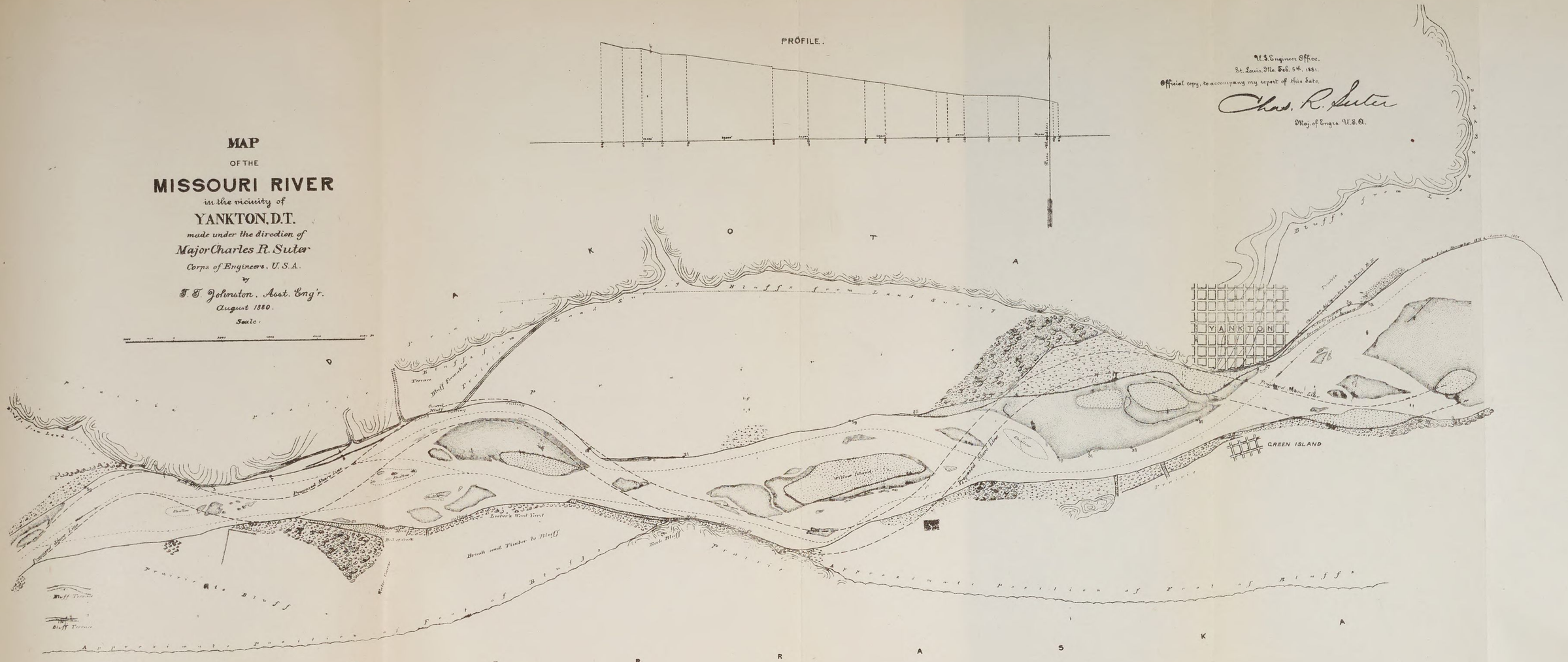
The stage of the river at the time of the survey was about $2\frac{1}{2}$ feet above ordinary low-water; in other words, about half way between low-water and middle stage, the average range on the Yankton guage being about 12 feet.

The condition of the river, observed at such times as opportunity afforded, was as follows: The river comes into the reach after following an eroded bank for $1\frac{1}{2}$ miles or more, and in endeavoring to cross to the left, is divided into two channels, which remain quite distinct from each other for about 8 miles. Steamboats ran in both of these channels at the time of the survey. They are completely separated throughout

MAP
OF THE
MISSOURI RIVER
in the vicinity of
YANKTON, D.T.
made under the direction of
Major Charles R. Suter
Corps of Engineers, U.S.A.
by
F. T. Johnston, Asst. Eng'r.
August 1880.
Scale:

PROFILE.

U.S. Engineer Office.
St. Louis, Mo. Feb. 5th, 1881.
Official copy, to accompany my report of this date.
Chas. R. Suter
Maj. of Engrs. U.S.A.



the greater part of their length, as shown on the map, by the emerged bars, islands, and the soundings. The right bank had been, and still was at places (as shown on the map), cutting throughout the whole length of the reach, except from △ 64, to below the rock-bluff point. The same is true of the left bank, from the upper rock-bluff to the head of the bar (△ 5) above Yankton, except in the immediate vicinity of △ 37, and △ 36; and below ⊙ 37, also, *rapid* erosion was in progress.

It is to be observed, also, that both the Willow Islands above Yankton have been narrowed. It appears that the high-water width of the river has been increasing. Since this fact bears some relation to the slope, it may be noticed that the river in this reach has a grade somewhat greater than its valley, the latter being the longest, and a study of the map will show this to be a condition to which the river has been coming. As the river now practically has its shortest possible length, this condition of the river is at a climax, with perhaps a tendency to retreat therefrom; and this reach presents an interesting specimen of a portion of the Missouri River, gradually shortened as much as possible. The tendency of the river to lengthen is shown in the bend around the upper island, though the smaller channel at the time of the survey, and in the retreating of the right bank above Green Island, which is allowing the bar in front of Yankton to extend. This direction of the tendency to lengthen is in the direct course of previous action of the river, and was probably inaugurated before the river attained its maximum slope. It is decidedly detrimental to the interests of Yankton, and must become more so.

The two channels above mentioned unite at the foot of the lower island, and flow along the eroded right bank until opposite Yankton, where the main body of water (a little going through the chute on the right) crosses to the left bank, which, as above stated, is giving way fast. The direct cause of the severity of the evil in this reach appears to be the increased slope of the river, due to the shortening of it, enforced by the topography of the valley; the climax of this condition of affairs being reached, its severity will doubtless decrease, though it must necessarily be felt for a long time, and much damage be the consequence.

As to materials apt to be used in improving the river at Yankton, the following may be said:

Willows and brush are scarce, and, as they grow, useless. The willows are most all small, averaging perhaps a height of five feet. Their localities are shown on the map. Cottonwood is the only timber, and, as the map will show, is not plentiful and its growth is not thick. There is any quantity of rock, hard enough for every purpose, anywhere in the bluffs. Large grass is plentiful now, and though when cut away several times, may grow up too fine for use. The propensity of sunflowers for prolific growth may be utilized in cultivating them; and their stalks, which are thick and tough—growing 1 inch and over in diameter, and 10 to 15 feet high—used in mattress-work.

The benefits to be conferred by any improvement of the river at Yankton may be stated as follows:

Facility of navigation would be increased in what is now a very bad place or reach of river—much worse than the average. A permanent rock bluff landing would be restored to Yankton, which is now, and has been for several years past, a prominent shipping point to the Upper Missouri. The destruction of much valuable property—land and railroad approaches to the town—would be stopped.

Very respectfully, your obedient servant,

THOS. T. JOHNSTON,
Assistant Engineer.

CHAS. R. SUTER,
Major, Corps of Engineers, U. S. A.

S 24.

SURVEY OF MISSOURI RIVER IN THE VICINITY OF NIOBRARA, NEBRASKA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 5, 1881.

GENERAL: I have the honor to submit herewith a copy of a report of Assistant Engineer T. T. Johnston, on the survey which he made, under my direction, of the Missouri River in the vicinity of Niobrara, Nebr., during the past summer. Mr. Johnston's report, with the accompanying map, will explain the condition of affairs in this neighborhood.

It will be seen that very extensive bars have formed in front of the town of Niobrara, which render access to it from the river both tedious and difficult. As considerable interests are connected with the transfer of freight and passengers from the railroad terminus opposite to the town, it is desired that these obstructions shall be removed. I find that the main channel is against the bluffs on the opposite shore, that it is in good condition and in a most desirable location. Its direction could not possibly be changed so as to be at the same time against the town front and at the railway terminus opposite, as the river bed is too wide.

The only way that occurs to me of meeting this difficulty is to build up the bars in front of Niobrara till the shore line is thrown forward to the deep water of the present channel, when the trouble complained of will no longer exist. To accomplish this work and to insure its stability it will be necessary to rectify about fifteen miles of river. I have indicated the proposed shore lines on the accompanying map, the whole improvement being based upon the principles laid down in my report on the river below Sioux City. The methods of construction recommended in that report should be employed here. The width between high-water shore lines, 900 feet, is believed to be adequate to insure the desired results, and to give a good navigable depth throughout the reach at the lowest stages of the river.

It is estimated that the proposed improvement will cost at the rate of $10,000 per mile, or $150,000 for the entire work, which can be expended in one season.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. THOS. J. JOHNSTON, ASSISTANT ENGINEER.


LEACHE'S MILL, MO., *November* 10, 1880.

MAJOR: I have the honor to submit the following report of the survey of the Missouri River at Niobrara, Nebr., made by me under instructions from you dated August 16, 1880.

This survey was conducted in the same manuer as the one at Yankton. The grade of the river throughout the length of the reach was 0.92 feet per mile; the length of the river surveyed was 15 miles, nearly. The accompanying map shows the result of the work, concerning which the following may be said:

The stage of the river at the time of the survey was the same as at Yankton. The river comes into the reach along a slowly eroded bank on the left. This it follows till near the head of the upper island, where, at a gumbo point, the river leaves it and crosses to the right. Sweeping around the island it comes back to the left at the rock bluffs, leaving a tenacious gumbo point on the right; leaving the bluff a short distance below, it follows, in an easy curve, an eroded bank till about one mile above the mouth of the Niobrara River, when it crosses to the right to a tough bank, just missing the rock bluff, along which it has recently flowed; at the mouth of the Niobrara River it bends back toward the left, and crossing, comes to the rock bluff opposite Niobrara; on this crossing is the only place in the reach difficult of navigation. The river continues down the bluff to Running Water; then leaving the bluff its channel continues along the slowly eroded, convex left bank, to the foot of the reach. As will be seen by the map, the river in this reach is *now* in a peculiarly good shape for the interests of navigation, and no destruction of valuable property is going on. The bar in front of Niobrara has extended enough to almost prevent the ferry-boat from crossing to the town, and before long will completely do so; however, a good landing can be had about 1½ miles above the town, where the railroad company has located cattle-pens. As to materials for construction, the same is true as has been stated with regard to Yankton.

The Niobrara River now comes into the Missouri on the channel side, and brings


MAP
OF THE
MISSOURI RIVER
in the vicinity of
NIOBRARA, NEB.
made under the direction of
Major Charles R. Suter
Corps of Engineers. U.S.A.
by
T. T. Johnston. Asst. Eng'r.
Sept. 5-17th 1880.
U.S. Engineer Office
St Louis, Mo. Feb. 5th, 1881.
Official copy, to accompany my report of this date.
Chas. R. Suter
Maj. of Engrs. U.S.A.
Magnetic Meridian
D A K O T A
Prairie
Proposed Shore Line
Prairie to Bluffs
Willow Island
Cattle Pens
Channel
Ferry Line
Shallow
NIOBRARA
Lost Creek Valley
PROFILE.
PONCA RESERVATION
N E B R A S K A

in a great deal of rather coarse sand; its slope is more than 15 feet per mile; not long hence the bend above will drop down to the mouth of this river, and may give source to evil influences on navigation.

The benefits that will be conferred by any improvement of the river here may be stated as follows:

Easy navigation can be maintained and furthered, with comparative ease and cheapness, by working on the river in its present condition.

The Chicago, Milwaukee and Saint Paul Railroad crosses the river here, and works can now be easily placed to prevent damage in future to this class of commerce.

The destruction of property, the value of which must soon amount to considerable, can be prevented.

Very respectfully, your obedient servant,

THOS. T. JOHNSTON,
Assistant Engineer.

CHAS. R. SUTER,
Major, Corps of Engineers.

S 25.

SURVEY OF THE MISSOURI RIVER FROM TUQUE CREEK TO ONE MILE WEST OF CHARETTE CREEK, WARREN COUNTY, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 4, 1881.

GENERAL: I beg leave to submit the following report on the condition of the Missouri River in the vicinity of Washington, Mo., designated in the river and harbor act as "from Tuque Creek to 1 mile west of Charette Creek, Warren County, Missouri":

The accompanying map of surveys, made in 1879 and 1880, shows the locality.

The river leaves the bluffs which border the right bank about 8 miles above Washington, Mo., and after making a broad sweep to the left, and reaching to within a mile of the left-hand bluffs, it again touches the right-bank bluffs at the town of Washington. The left bank throughout this distance is composed of light sandy soil, which is very easily eroded. After leaving the bluffs the two creeks, Tuque and Charette, meander through this rich bottom, and finally empty into the river, as shown on the map. An inspection of the map shows that the apex of this great bend was at one time at the mouth of Charette Creek; subsequently it moved down stream and Charette Bend became silted up. Until within a few years there was a navigable channel on each side of Saint John's Island, the best water being at times in the bend and at times in the chute. Within a few years, however, excessive erosion in Emily Bend, just above, caused the channel in Charette Bend to change, and now the accretions in front of Charette Creek have been nearly all swept away, while the whole front of the rich Charette bottom is being attacked by the river. The channel to the right of Saint John's Island is nearly closed, and the erosion of the left bank, about 3 miles above Washington, threatens to wear away the point and ultimately destroy the harbor of Washington.

This whole reach offers extreme difficulties to navigation. It is in fact one of the worst places on the river, being very wide, obstructed with sand bars, while the channels are shallow and constantly shifting.

The improvement proposed contemplates the complete rectification of the reach from Patton's point to the town of South Point, a distance of 10 miles.

This work should be carried out in accordance with the principles laid

down in my general report on the Missouri River, and the methods of construction there described should be employed.

The proposed shore lines indicated on the map are those of high-water, and are 1,300 feet apart. The low-water shore lines will lie inside of these and will be about 1,100 feet apart. When the rectification is completed, the banks raised to full height and protected from further erosion, it is expected that a depth of 12 feet at extreme low-water will be available.

On account of the unusual amount of work required at this place, I estimate the cost of the proposed improvement at $12,000 per mile, which will make the total cost $120,000. This sum can be expended in one season.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

S 26.

SURVEY OF MOUTH OF GRAND RIVER AND MISSOURI RIVER AT BRUNSWICK, MISSOURI.

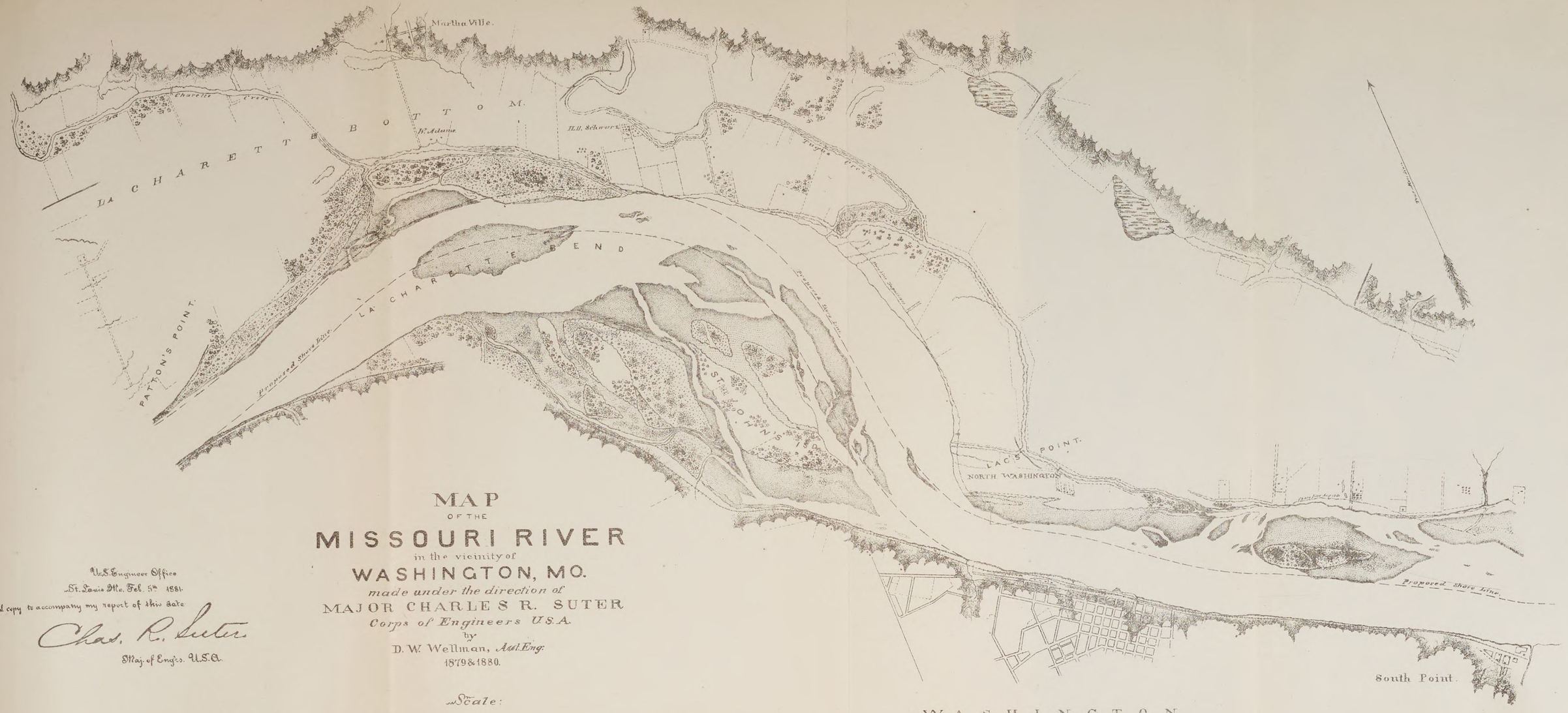
UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 5, 1881.

GENERAL: I beg leave to submit the following report upon the condition of the Missouri River near Brunswick, Mo., designated in the river and harbor act of June 14, 1880, as "Mouth of Grand River and Missouri River at Brunswick, with reference to boat landing at Brunswick, Mo.":

The accompanying map will explain the situation. It gives the lines of the surveys made in 1878 and 1880, and also the shore lines given by the Land Office maps of 1817.

The town of Brunswick was originally located on the bank of the Missouri at the mouth of Grand River. The Missouri here made a sharp left-hand bend, leaving a peninsula opposite the town known as Paddock's Point. The bends which bounded this peninsula were Grand River Bend, Brunswick Bend, and Columbian Bend. As time went on Grand River Bend gradually silted up, and the erosion on the upper side of Paddock's Point was accompanied by the formation of extensive battures near the mouth of Grand River. Finally, about 1874, the point was reduced to such small dimensions that it was entirely cut away, and the river now follows a nearly direct course from a point about 2 miles below De Witt to a point about 2½ miles below Brunswick. Columbian Bend has been silted up, as well as Brunswick Bend, while Grand River now flows out through this latter bend, its water being only able to keep open the small channel proportioned to its size. All the rest of the old bed of the Missouri is thickly grown up with willows. As a result of these changes, Brunswick was left several miles from the main river, and the town landing is established at the present mouth of Grand River, 2½ miles from the town proper. The town is located on the Saint Louis, Kansas City and Northern Railroad.

As I understand the wishes of those parties who are interested in the



MAP
OF THE
MISSOURI RIVER
in the vicinity of
WASHINGTON, MO.
made under the direction of
MAJOR CHARLES R. SUTER
Corps of Engineers U.S.A.
by
D. W. Wellman, *Asst Engr.*
1879 & 1880.

Scale:

U.S. Engineer Office
St. Louis Mo. Feb. 5th 1881.
Official copy to accompany my report of this date.
Chas. R. Suter
Maj. of Engrs. U.S.A.

MAP
of the
MISSOURI RIVER
in the vicinity of
BRUNSWICK, MO.
made under the direction of
MAJOR CHARLES R. SUTER
Corps of Engineers USA.
by
D. W. Wellman, Ast Eng.
1878 & 1880.

U.S. Engineer Office
St Louis Mo. Feb 5th 1881
Official copy to accompany my report of this date.
Chas. R. Suter
Maj of Engrs. U.S.A.

BRUNSWICK.

Grand River

LAKE

OLD BRUNSWICK BEND.

MAGENTA BEND.

GRAND RIVER BEND.

CUT OFF.

PADDOCK'S POINT.

DEWITT.

COLUMBIAN BAR.

COLUMBIAN BEND.

BRUNSWICK ISLAND

STONEWALL POINT.

True Meridian

Scale:

Shore Line of 1878 ——
" " " 1880 - - - -
" " " 1817 —·—·—

matter, their desire is to restore Brunswick to its former position on the river.

Many plans have been suggested, the favorite, apparently, being to cut a canal through from the Missouri River to Grand River, and by thus increasing the flow of the latter to keep open a navigable channel past Brunswick. This plan I do not regard as advisable, or even feasible. It would, however, undoubtedly be possible to restore the channel of the Missouri to something like its position in 1817, but very extensive works would be required, the land damages would be enormous, and the cost would probably run up to millions. This expenditure could clearly only be justified by much larger interests than seem to be involved here.

The mouth of Grand River is now obstructed by the annual deposits of mud from the Missouri, which cannot well be prevented, and also by snags, which can undoubtedly be removed. I think that when this is done boats can ascend Grand River to Brunswick at high-water, if they so desire, but at low-water the present landing, 2½ miles below the town, will probably be the nearest point that they can reach.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX T.

IMPROVEMENT OF MISSOURI RIVER ABOVE MOUTH OF YELLOWSTONE—IMPROVEMENT OF YELLOWSTONE RIVER.

REPORT OF CAPTAIN EDWARD MAGUIRE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 13, 1881.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river improvements in my charge, for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
Captain of Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*

T 1.

IMPROVEMENT OF THE MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

Last season the work of improving the Missouri River above mouth of Yellowstone was carried on in two distinct sections of the river, viz, above the Great Falls and below Benton.

THE WORK ABOVE THE GREAT FALLS.

One assistant engineer, accompanied by an overseer and blacksmith, left Saint Paul July 18, 1880, and arrived at Stubbs Ferry August 11. The material was all purchased and the boats finished by September 1. It was very difficult to hire laborers and mechanics at all, and impossible to obtain first-class men.

The experiment of employing Montana labor has been made now, and it has proved a failure. On September 3, work was commenced at Bear's Teeth Shoal. The river at that point is divided into three channels by two islands. The shoal lies at the head of the lower island, and had less than 2 feet of water on it at the time of the survey made during April and May, 1880. The Montana Navigation Company had undertaken to improve this shoal. They closed the upper chute with a stone dam, and built about 150 feet of a dam to close the lower chute. The upper dam had a large break in it, made by the ice. This was temporarily repaired, and the lower dam completed. A dam was then built

above the upper one. The immediate result of this work was an increase of depth on the shoal to full 2½ feet. There were 822 cubic yards of stone placed in these dams. The work was finished September 28. On October 1, work was commenced at Bear's Teeth Rapids. At this point 93 cubic yards of stone were taken out of the river, clearing a channel 70 feet wide to a depth of 2½ feet scant.

On October 25, work was commenced at Lone Pine or Half Breed Rapids. At this point a channel 100 feet in width was cleared, necessitating the removal of 106 cubic yards of stone.

On November 5, the season's work was closed, the laborers paid off and discharged in Helena. The assistant engineer and overseer arrived in Saint Paul November 24.

THE WORK BELOW BENTON.

A party, consisting of Assistant Engineer Stevens, one recorder, two overseers, two suboverseers, and fifty-six men, left Saint Paul July 22 and arrived at Chimney Bend, where the boats and tools were stored, August 4. The necessary work of preparation was completed August 6 and the camp moved the following day to McGarry's Bar, 2 miles below Dauphin's Rapids. At this point a coarse gravel shoal, with a steamboat depth of 2 feet, crosses the river above a gravel bar. A stone dam was built from the right bank, crossing the crest above the dry bar. The effect of the dam was to secure a channel of sufficient depth, and boats have had no trouble there since. The dam contains 1,257 cubic yards of stone, is 505 feet long, and with a crest of 12 feet. Most of the stone was procured from one-half to one mile below the dam. The work of cordeling the stone-boats was very tedious and expensive. In order to obtain the requisite amount of stone within the above-mentioned distances much of it had to be taken from the bluffs from 500 to 1,000 feet from the river. The work was completed August 24, and the camp was moved the following day to Little Dog Rapids.

In March, 1880, the ice gorged on the Dauphin's Dam, and, extending across the river, the water was raised 35 feet. Upon its subsidence it was found that about 200 feet of the dam near the shore end had been carried away. An entirely new dam was built at this point with a greater inclination down stream. It is 703 feet long, with a thickness varying from 27 to 12 feet. It contains 1,706 cubic yards of stone and 760 fascines. The fascines are about 1 foot in diameter and from 12 to 16 feet in length. This work was completed September 14. The following day a party of 22 men was moved to Snake Point, and the remainder of the force commenced the removal of rock from Little Dog Rapids. At these rapids there are two reefs, about three-fourths of a mile apart, and between them were scattering rocks, projecting from deep water. A channel 100 feet in width, 5,100 feet in length, was carefully cleaned to a depth of 3 feet, except for a distance of 700 feet over the upper reef, where the uniform gravel bottom was only 2½ feet below the surface. There were 40.2 feet drilled, 49 blasts exploded, and 442 cubic yards of rock removed.

About 24 cubic yards of rock were removed from near the head of Dauphin's Rapids. Camp was moved to Bear's Rapids October 5. The rocky shoal at this point was short but very bad. The channel was cleared for 2,000 feet, most of the work being in a length of only 500 feet. There were 20.7 feet drilled, 55 blasts exploded, and 499½ cubic yards of stone removed. This work was completed and camp moved to Gallatin Rapids October 21.

At Snake Point the river is divided by an island, at the head of which a gravel shoal crosses both channels. The main flow of the water is to the left, a few large rocks obstructing the channel. A rock dam was built from the right bank, crossing the crest of the shoal above the island. A few of the prominent rocks were blasted down. The dam contains 1,696 cubic yards of stone; its length is 615 feet, and its width on top from 15 to 18 feet.

The season's work was closed October 24, when the party started for Saint Paul, arriving November 4.

The total amount of work done on the river was as follows:

Number of cubic yards rock taken out	1,164½
Number of blasts	104
Number of feet drilled	60.9
Number cubic yards stone placed in dams	5,481
Number of fascines placed in dams	760

In addition the survey was continued from Dauphin's to Gallatin Rapids, and a survey of Snake Point made.

The work during the coming season will be confined to the river below Benton. A dam will be built near Trover's Point. This will be a pile dam, unless stone be discovered nearer to the locality than I think it will. Bowlders will be removed from Buffalo Shoals, about 9 miles below Trover's Point. These two are the only very bad places below Grand Island. At the latter point the steamboatmen report the shallowest water on the river. The works at Grand Island will be repaired, strengthened, and extended. Gallatin Rapids will be cleared. Having now a steamboat for the work, time and money will be saved, and a great deal of work which cannot be definitely located, but comes under the head of "general clearing of the channel," will be accomplished.

It is gratifying to be able to report that the steamboatmen have cast away their hostility to the "government engineers," and now speak in unstinted praise of the work done and the effects produced. In 1877 the number of trips made above Cow Island after August 1 was one, last season there were twenty-three made.

STATISTICS.

Capt. E. B. Kirk, assistant quartermaster, United States Army, informs me that during last season there were shipped from the depot at Bismarck for points on the Missouri River 9,036,818 pounds of military stores.

Capt. D. D. Wheeler, assistant quartermaster, United States Army, informs me that during the season of 1880 there were shipped from Yankton to points on the Missouri River 15 head cattle, 11 horses, 135 mules, and 2,595,132 pounds of stores.

Lieut. Francis Woodbridge, Seventh Infantry, acting assistant quartermaster, informs me that during the season of 1880 there were shipped from Fort Buford, Dak., for the Upper Missouri River, 661,971 pounds stores and 1 horse.

From the River Press, of January 5, 1881, published at Fort Benton, I obtain the following information: The total amount of freight, exclusive of government freight, carried into the territory by the river was 16,913,693 pounds.

I have been unable to obtain a full exhibit of the exports, but the amount of wool shipped by the river was 600,000 pounds. It is safe to assume that the amount of other articles of export was not less than that of previous years.

The total shipments of hides, pelts, furs, &c., from the territory by rail and river, amounted to 680,000 pounds. The exports of Montana, crude and refined silver and other bullion, for 1880 amounted to 10,913,407 pounds. During the year there were 10,000 head of beef-steers driven to the eastern market and to the British possessions.

SUMMARY OF RIVER FREIGHT, EXCLUSIVE OF EXPORTS AND INDIAN DEPARTMENT FREIGHT.

	Pounds.
Private freight	16,913,693
Government freight from Bismarck	9,036,818
Government freight from Yankton	2,595,132
Government freight from Fort Buford, Dak	661,971
Government freight from Cow Island, Montana	3,362
Government freight from Coal Banks, Montana	48,219
Government freight from Fort Benton, Mont	48,845
Total	29,308,040

Or about 14,654 tons.

My thanks are due to assistant engineers Stevens and Wood for close attention to and excellent execution of the work assigned to them.

Money statement.

July 1, 1880, amount available	$46,551 88	
Amount appropriated by act approved March 3, 1881	40,000 00	
		$86,551 88
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	34,196 65	
July 1, 1881, outstanding liabilities	5,841 11	
		40,037 76
July 1, 1881, amount available		46,514 12
Amount that can be profitably expended in fiscal year ending June 30, 1883		150,000 00

T 2.

IMPROVEMENT OF YELLOWSTONE RIVER, MONTANA AND DAKOTA.

Last season the work of improvement of the Yellowstone River was carried on by two parties, one under the direction of Assistant Engineer F. M. Towar, consisting of one recorder, one overseer, and eleven men, working at Buffalo Rapids, and the other under the direction of Assistant Engineer J. J. Durage, consisting of one recorder, one overseer, and eleven men, working at Baker's and Wolf rapids.

Both parties left Saint Paul July 23, 1880.

The work at Buffalo Rapids was recommenced August 16, and continued until October 26, when the season's work was closed. There were 303 cubic yards of rock removed, requiring about 138 feet of drilling and the explosion of two hundred and seventy-three blasts. In addition a large amount of rock was blown into deep water, of which there can be no estimate made. During the last two seasons a channel, varying from 100 to 150 feet in width and 8,800 feet long, was cleared. At the lower end of the rapids a channel of from 150 to 180 feet in width and from 3 to 5 feet in depth was made. The slope has been very materialy reduced and steamboats seldom use a line now.

At Baker's Rapids the channel used by the steamboats was cleared

to a depth of 3 feet and for a width varying from 120 to 180 feet. Ranges and turning-posts were established, as also a crib, to which lines can be laid. There were 462½ feet drilled, two hundred and fifteen blasts exploded, 99 cubic yards of rock taken out, and a large quantity blown down into deep water. This work was commenced August 23, and finished September 24, when the party moved to Wolf Rapids. At this point the river is divided into two channels (both obstructed by ledges) by a large rock about 100 feet long and from 30 to 50 feet wide. I ordered the work done on the left channel. The water there flowed over seven ledges, from 20 to 30 feet apart, some of them holding only about 3 to 4 inches of water, and none of them over 1 foot. A channel 300 feet long, 100 feet wide, and 3 feet deep was obtained, and a large quantity of water from the right channel drawn in. There were 384 feet drilled, two hundred blasts exploded, 313 cubic yards of rock blown down into deep water, and 271 cubic yards of rock removed.

The work done at all of these points has materially benefited navigation, but more work is needed at Baker's and Wolf rapids, as well as intermediate points.

The total amount of work done on the river during the season was as follows:

Number cubic yards rock taken out	519
Number of blasts	688
Number of feet drilled	984½

A large quantity of rock was blown down into deep water. The nature of the material of which the ledges were formed necessitated a great deal of drilling and many blasts for the work. Comparatively few bowlders were encountered.

During the coming season two large parties will be placed in the field. The work will consist in building dams just above Buffalo Rapids; near Custer Creek; near De Russy's Rapids; near the town of Glendive; and at Beef Slough, and in removing rock at a point about 6 miles below Buffalo Rapids; at a point about 14 miles below Buffalo Rapids, and in completing the work at Baker's and Wolf rapids.

STATISTICS.

Capt. E. B. Kirk, assistant quartermaster, United States Army, informs me that during last season there were shipped from the depot of Bismarck, for points on the Yellowstone River, 2,192,173 pounds of military stores.

Capt. D. D. Wheeler, assistant quartermaster, United States Army, informs me that during the season of 1880 there were shipped from Yankton to points on the Yellowstone River 30 mules and 479,015 pounds of stores.

Lieut. Francis Woodbridge, Seventh Infantry, acting assistant quartermaster, informs me that during the season of 1880 there were shipped from Fort Buford, Dak., to points on the Yellowstone River, 1 horse and 222,268 pounds of stores.

Capt. A. R. Ninnenger (formerly captain United States Army) informs me that the exports of Montana last season by the Yellowstone amounted to about 600 tons of hides, pelts, furs, &c.; that shipment will be nearly double this season. New towns are springing up in the valley, and the settlements are rapidly increasing.

Maj. F. P. McElrath, land commissioner at Miles City, informs me that there were twenty-four steamboat arrivals at Miles City during the sea-

son of 1880, averaging 250 tons of freight per boat, or a total of 6,000 tons, which included government freight.

SUMMARY OF RIVER FREIGHT, EXCLUSIVE OF INDIAN DEPARTMENT FREIGHT.

	Pounds.
Exports	1,200,000
Private imports	8,810,319
Government freight from Bismarck	2,192,173
Government freight from Yankton	479,015
Government freight from Buford	222,268
Government freight from Big Horn Depot	22,138
Government freight from Fort Keogh	274,087
Total	13,200,000

Or about 6,600 tons.

My thanks are due to Assistant Engineers Towar and Durage for close attention to and excellent execution of the work assigned to them.

Money statement.

July 1, 1880, amount available	$29,423 13	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$49,423 13
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	16,937 55	
July 1, 1881, outstanding liabilities	4,829 70	
		21,767 25
July 1, 1881, amount available		27,655 88
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

APPENDIX U.

IMPROVEMENT OF THE NAVIGATION OF THE MISSISSIPPI RIVER BETWEEN SAINT PAUL AND THE MOUTH OF THE ILLINOIS, INCLUDING IMPROVEMENTS AT SPECIAL LOCALITIES BETWEEN THOSE POINTS—IMPROVEMENT OF GALENA RIVER AND HARBOR, ILLINOIS—IMPROVEMENT OF CUIVRE RIVER, MISSOURI.

REPORT OF CAPTAIN ALEXANDER MACKENZIE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 4, 1881.

GENERAL: I have the honor to transmit herewith the annual reports of operations under my charge during the fiscal year ending June 30, 1881, and as an appendix a progress report (with maps and plates*) upon the work, with current meters, carried on near Burlington in 1878 and 1879.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

U 1.

OPERATIONS OF SNAG-BOAT IN IMPROVEMENT OF UPPER MISSISSIPPI RIVER.

Under this appropriation has been operated during the past year the snag and dredge boat General Barnard. The season's operations are fully set forth in the appended report of Assistant Engineer C. W. Durham, to whom much credit is due, not only for the effective work of the snag-boat, but also for the valuable information collected in the interests of navigation, and for assistance rendered in carrying on the various works of improvement along the river.

The river and harbor act of March 3, 1881, provided for the construction of a light-draught steamboat to be used in connection with the General Barnard. The original estimate for this boat, which was thought to be ample, was $15,000, but the recent increase in cost of labor and material may increase the cost to about $20,000. This boat will be built during the coming winter.

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* Not printed.

An important duty performed by the snag-boat in connection with its ordinary work is the frequent and practical examination of all bars on this section of the Mississippi River. This work, which is done without extra expense, furnishes most valuable information in tracing the action of the river, and in the selection of points and preparation of plans for improvement. The same amount of information could only otherwise be obtained by expensive and continuous special surveys.

The annual low-water trip of this boat over the river, the relative difficulties met with, and the highest point reached in successive years, furnish the best possible evidence of the result of the works of improvement being carried on. At many points where trouble arises from change of channel or from the formation of a number of channels, the regular packets discover many of these changes, but they usually have no time to investigate and sometimes do not take advantage of the best water when even a few inches is of so much importance. Each season the snag-boat has discovered and marked out a number of such channels, thereby greatly facilitating navigation. The small amount of appropriations, the expense attending the running of the boat, and the local work required, do not permit of many trips during the season, and not as much of this work can be done as is desirable, but it is hoped that in the future, with the aid of the additional boats now employed on improvements, more work can be done in this direction.

Amounts of appropriations heretofore recommended have been invariably reduced by Congress, and had not alotments been made from the general appropriations the work of the snag-boat would have been seriously impaired. This work being of great importance to the interests of navigation, both directly in the ordinary operations of a snag-boat, and indirectly through the assistance furnished the various branches of improvement, the appropriation under which it is carried on is an important one, and as the estimates are based on the actual cost of operating the boat, more serious injury results from a reduction than when ordinary appropriations are under consideration. I would therefore respectfully recommend, for operating expenses of the General Barnard and the light-draught boat to be built in the coming winter, an appropriation of $30,000 for the fiscal year ending June 30, 1883.

As bearing upon the general improvement of the Upper Mississippi rather than any special locality or section, I submit the following in connection with this report:

SHEER-BOOMS.

While all bridges crossing the Mississippi are to a certain extent obstructions to navigation, the necessity for their existence is acknowledged, but it is of great importance that all possible means be employed to render them the least troublesome and dangerous, and make their passage by boats and rafts comparatively safe. An act of Congress approved March 3, 1875, calls for an inquiry into the expediency of establishing sheer-booms at bridges, and the report of a Board of Engineers, appointed for the purpose of considering the matter, submitted to the honorable the Secretary of War February 19, 1877, recognizes the necessity of such work and presents plans for the various bridges. A statement submitted to Congress in 1880 by the river interests presents very clearly the importance of booms or other works for facilitating navigation at the various bridges, and, as a means of more speedy and reliable accomplishment of this work, asks for an appropriation by Congress. Knowing the great necessity of the work, but having no

means at my disposal for carrying it out, I have corresponded with several of the bridge companies, but as yet have accomplished but little, and it cannot be expected that these companies will voluntarily look upon the matter in the same light as those interested in navigation or improving the river. It is of great importance that some action should be taken by Congress, either compelling the railroad and bridge companies to put in such works as may be deemed necessary, or that an appropriation for the improvement be made.

The plans submitted by the Board of Engineers would, in the light of more recent experience, require some modifications, and if this work were to be done by the government, it would in my opinion be desirable to revise these plans after consultation on the ground with the most experienced raft-boat and packet pilots. Until such plans are prepared it is impracticable to give the cost of work, but an approximate estimate for all the bridges would be $100,000.

SAWDUST.

There was referred to me last month a communication addressed to the honorable the Secretary of War, by the Saint Paul Chamber of Commerce, and relating to the deposit of sawdust in the Mississippi River. By indorsement of the Chief of Engineers, I was requested to give the matter my attention with a view to presenting the matter to Congress in this report. Having no funds available for a special examination, I must depend for my information upon the records and such facts as are gathered in connection with the improvement of the river. Since the receipt of this communication the Assistant Engineer in charge of the section of the upper river materially affected by the deposit of sawdust, has been so busily employed in connection with the works of improvement that no new information has been obtained. As based upon general information and records of the office, I can say that at all points where improvements have been made above Lake Pepin, it is shown that many of the bars are largely composed of sawdust. It has also been found in the bars as far down as Winona. That the promiscuous depositing of sawdust in the river is a public evil, and liable to injure navigation, has been acknowledged by all, who, from their connection with the river improvements, have had occasion to practically investigate the subject; and Congressional or State legislation prohibiting deposit of sawdust or other refuse in the Mississippi River, would seem very necessary. The river and harbor act of August 14, 1876, directed the Secretary of War to report to Congress what legislation was necessary for the preservation of public works. A full report on this subject and form of act is found in the Report of Chief of Engineers for 1877, but as yet Congress has taken no action on this subject.

LIGHTING THE DAMS.

It is very important that lights should be kept up at the ends of certain of the spur dams at certain stages of the river. As a rule the channel passes near them, and on dark nights it is difficult for a pilot to locate them. The necessity of this work is fully recognized, and I think arrangements will soon be made by the Light House Department for carrying it out. Should their appropriation be insufficient for this work at present, I believe the lights are a sufficiently important accessory to certain of the dams to warrant the temporary establishment of these lights, the cost to be paid from the general appropriation for improvement of the river.

WATER GAUGES.

During the past year daily gauge readings have been obtained at the following points: Redwing, Hastings, Alma, McGregor, Winona, Lansing, Clinton, Le Claire, Burlington, and Perugue Island. The readings at Saint Paul, Saint Louis, Dubuque, and La Crosse, are furnished by the courtesy of the Chief Signal Officer of the Army. These records are obtained at trifling expense and will prove of great benefit in considering certain river phenomena. Some arrangement is desirable by which the stage of the river at various points may be more generally published in the daily papers for the benefit of navigators. This, if now done, must be at the papers' expense, and in individual cases the returns would not justify the excessive cost. This information would be of great assistance in loading vessels, and in estimating the progressive effect of floods, &c.

ICE HARBORS.

The establishment of several ice-harbors on the upper river is of great importance, but few now existing; and to avoid damage by ice most of the boats must be hauled out on ways for the winter. The necessity of these harbors was fully demonstrated during the past winter, and if the loss due to their absence were known, I have no doubt it would go far towards carrying out the desired work.

PIERS.

In accordance, as claimed, with authority granted by section 5254 of the Revised Statutes of the United States, piers are continually being built by the various lumber firms and others in the river, but in few cases, as far as is known to this office, has any action been taken by those building them which has permitted previous consideration of the special cases. Such special examination is necessary; and while no work of this kind yet done interferes with general navigation, the habit, if continued, may cause trouble.

IN GENERAL.

The preliminary report of the "Mississippi River Commission" on the Upper Mississippi River, from Falls of Saint Anthony to the mouth of the Missouri River, submitted to Congress March, 1881, and printed as H. R. Ex. Doc. No. 95, Forty-sixth Congress, third session, contains, as Appendix C, certain memoranda relating to the improvement of the river, giving a history of work in the past and projects for the future; also, as Appendix D, a circular letter addressed to those interested in the navigation of the river, and the replies received thereto.

A pamphlet published by the combined lumbering interests of the Mississippi, and presented to Congress during its last session, also contains much useful information to those interested in the river navigation, and presents the most cogent reasons for granting liberal appropriations for continuing the work now commenced. The committee state in their memorial as follows:

> The evidence that the work already done under the supervision of the government engineers has benefited very materially the commerce of the river, is abundant, complete, and conclusive.

Money statement.

July 1, 1880, amount available	$11,840 52	
Amount appropriated by act approved March 3, 1881	25,000 00	
		$36,840 52
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		8,493 93
July 1, 1881, amount available		28,346 59
Amount that can be profitably expended in fiscal year ending June 30, 1883		30,000 00

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1881.

CAPTAIN: I have the honor to present my annual report on "improving Upper Mississippi River" for the fiscal year ending June 30, 1881, together with some statistics of commerce and navigation. During the spring of 1880 the snag-boat General Barnard was put in thorough repair, and on July 20 began her season's work.

From July 20 until October 30 she was employed, as heretofore, between Saint Paul and the mouth of the Missouri River in removing snags, impending trees, wrecks, &c., dredging, assisting steamboats, establishing water-gauges, buoys, and channel-marks, making surveys and reconnaissances, transporting government property, and rendering occasional service to the works of permanent improvement. Between November 1 and 4 a portion of the crew were engaged in laying her up in winter quarters at Quincy, Ill.

During the season of 1880 excellent service was performed at several localities, among which may be mentioned the removal of snags at or near Kaposia, Pine Bend, Diamond Bluff, Crat's Island, Beef Slough, Betsy Slough, Picayune Chute, Coon Slough, Crooked Slough, Cassville Slough, Tully Island, Louisiana, Clarksville, Dardenne Island, Enterprise Island, and Westport Chute.

In August examinations were made at Gilbert's Island, Cuivre River, and Smith's Bar.

In October the Barnard made an inspection trip from Hastings to Saint Louis with "Mississippi River Commission" on board, and also a hydrographic survey of about 6 miles of river in vicinity of Louisiana, Mo., and Krider's Bend. During the season soundings were frequently taken on the bad bars and crossings, and results recorded.

An extremely high-water stage occurred in July, 1880, it being the highest known on a portion of the upper river. In order to ascertain the high-water elevations at various points, and the high-water slope of the river for future reference, levels were taken, bench-marks established, and results recorded.

SUMMARY OF OPERATIONS OF UNITED STATES STEAMER GENERAL BARNARD, SEASON OF 1880.

Snags removed	265
Leaning trees pulled back	47
Leaning trees felled	4,351
Steamboats assisted	4
Dredging, hours	15
High-water elevations taken	46
Miles run	3,994

During April and May, 1881, the General Barnard was put in readiness for service, and on the 21st of May began her season's work. From that date until the close of the fiscal year she was employed between the mouth of the Missouri River and Rock Island, Ill., and in Cuivre River, Missouri.

RIVER NOTES.

During July, 1880, occurred a very high stage of water, and the river was at a good boating stage until the latter part of August, from which time until the end of the season the river was quite low, and the larger boats went up stream no farther than La Crosse or Winona, the lighter ones stopping at Hastings, which is 27 miles below Saint Paul. I give a list of channel depths on some of the worst bars at the lowest-

water periods of 1880: Robinson's Island, 1 foot 8 inches; Nininger Slough, 3 feet; head of Prescott Island, 4 feet; above Wabasha, 3 feet 7 inches; Crat's Island, 3 feet 6 inches; Beef Slough, 3 feet; Chimney Rock, 4 feet; Rolling Stone, 4 feet; Winona, 3 feet 6 inches; Dresbach, 4 feet; Grand Crossing, 3 feet 6 inches; Rush Chute, 4 feet; Gregory's Landing, 4 feet; Tully Island, 4 feet; Smoot's Bar, 3 feet; Wyaconda, 4 feet; Gilbert's Island, 3 feet 6 inches; Mundy's Landing, 3 feet 6 inches; Dardenne Island, 5 feet.

The following table shows observed channel depths on the worst bars in 1880 and the stage of the river at the time of the observation, from which we estimate and give the theoretical depth at extreme low-water; the actual depth at low-water would be generally somewhat greater than the depth given, owing to the scour on the reefs which ordinarily takes place when the water reaches a very low stage.

List of bars and channel depths on Upper Mississippi River, season of 1880.

Name of bar.	Date.	Observed depth.	Stage above low-water of 1864.	Theoretical depth at loww-ater.	Remarks.
	1880.	*Feet.*	*Feet.*	*Feet.*	
Frenchman's	July 31	3.5	3.5	0.0	Very bad obstruction just below Saint Paul; only 30 inches water at the lowest stage in 1880.
Kaporia	July 29	5.0	3.5	1.5	Bad crossing.
Island No. 2	July 29	5.5	3.5	2.0	Sometimes bad, but quite good in 1880.
Red Rock	July 29	4.5	3.5	1.0	Two bad crossings.
Above Newport	July 29	4.5	3.5	1.0	Much improved by construction of dams, &c. Not less than 3½ feet in 1880.
Below Newport	July 29	4.3	3.5	0.8	Good in 1880.
Robinson's Island	July 29	4.0	3.5	0.5	The worst obstruction in 1880; this bar prevented the small steamboats from reaching Saint Paul. Only 20 inches in the channel at the lowest water of the season.
Island No. 10	July 29	6.0	3.5	2.5	Much better than for several years previous.
Boulanger's	July 29	6.5	3.5	3.0	Good in 1880.
Nininger Slough	July 29	4.3	3.5	0.8	Had been good for several years, but a break in the dam built in 1875 caused a shoaling so that there were but 3 feet at the lowest water of the season. The break was repaired.
Do	Oct. 2	3.0	1.5	1.5	
Above Nininger	July 29	4.0	3.5	0.5	Tolerably good in 1880.
Below Nininger	July 29	5.3	3.5	1.8	Do.
Do	Oct. 2	4.0	1.5	2.5	
Below Hastings	Oct. 6	5.0	2.0	3.0	Improved by construction of dams, &c. Not less than 5 feet in 1880.
Head Prescott Island	Oct. 6	4.0	2.0	2.0	Improved by dams—4 feet in 1880.
Foot Prescott Island	Oct. 7	6.5	3.2	3.3	Good in 1880.
Island No. 20	Oct. 7	5.5	3.2	3.3	Do.
Smith's Bar	July 27	6.0	4.0	2.0	Worst bar below Prescott in 1878 and 1879. Now improved by dams, &c.
Do	Aug. 7	6.0	3.2	2.8	
Do	Oct. 2	6.0	1.5	4.5	Not less than 6 feet in 1880. Only 30 inches in 1879.
Head Lake Pepin	July 27	5.5	4.0	1.5	Very bad obstruction.
Below Read's Landing	July 27	6.5	4.0	2.5	Good in 1880.
Above Wabasha	July 27	5.5	4.0	1.5	Very bad in 1879. Not less than 3½ feet in 1880.
Do	Oct. 1	3.9	1.8	2.1	
Do	Oct. 7	3.6	2.0	1.6	
Crats Island (head)	July 27	7.5	4.0	3.5	Formerly very bad, but now improved by dams; 7½ feet in 1880.
Crats Island (foot)	Aug. 9	4.0	3.2	0.8	Very bad bar; about 3½ feet in 1880.
Do	Oct. 1	3.5	1.8	0.7	Works now constructed will probaly
Do	Oct. 7	3.5	2.0	1.5	effect great improvement.
Teepeeota Point	July 27	5.0	4.0	1.0	Bad bar. Works already constructed
Do	Oct. 1	3.9	1.8	2.1	will probably effect improvement.
Do	Oct. 7	3.0	2.0	1.0	
Beef Slough	July 27	5.5	4.0	1.5	Very bad bar, for many years the most
Do	Aug. 3	3.5	3.0	0.5	troublesome on the river. Works now
Do	Aug. 10	4.3	3.2	1.1	constructed will probably effect great
Do	Oct. 1	3.3	1.8	1.5	improvement.
Do	Oct. 7	3.0	2.0	1.0	
West Newton Island	Aug. 10	5.0	3.2	1.8	Very bad in 1880. Work of improve-
Do	Oct. 1	3.5	1.8	1.7	ment commenced.
Do	Oct. 7	3.9	2.0	1.9	
Mount Vernon	Oct. 1	5.5	1.8	3.7	Improved in 1879, formerly very bad; 5½ feet in 1880.

List of bars and channel depths on Upper Mississippi River, season of 1880—Continued.

Name of bar.	Date.	Observed depth.	Stage above low-water of 1864.	Theoretical depth at low-water.	Remarks.
	1880.	*Feet.*	*Feet.*	*Feet.*	
Chimney Rock	Aug. 10	4.5	3.2	1.3	Very bad obstruction to rafts on account of crookedness of channel.
Do	Oct. 1	4.0	1.8	2.2	
Do	Oct. 7	4.0	2.0	2.0	
Rollingstone	July 26	5.0	4.5	0.5	Formerly one of the worst obstructions on the river, but now much improved by dams.
Do	Aug. 10	4.5	3.2	1.3	
Do	Oct. 7	4.0	2.0	2.0	
Betsy Slough	July 26	6.0	4.5	1.5	Formerly very bad, now improved, not less than 5 feet in 1880.
Winona	Aug. 11	4.3	3.2	1.1	Very bad for several years, only 34 inches in 1879; 4 feet in 1880. Works now constructed will effect further improvement.
Do	Sept. 30	3.5	1.8	1.7	
Do	Oct. 7	4.0	2.0	2.0	
Homer	July 26	5.0	4.5	0.5	Bad in 1879.
Do	Aug. 12	4.5	3.2	1.3	
Lamoille	July 26	8.0	4.5	3.5	Good in 1880.
Queen's Bluff	July 24	8.5	4.2	4.3	Improved in 1878, formerly bad obstruction.
Dresbach	July 24	5.0	4.2	0.8	Very bad obstruction. River wide, with several minor channels.
Do	Aug. 12	4.0	3.2	0.8	
La Crosse	July 24	8.0	4.2	3.8	Improved by dams in 1878 and 1879.
Grand Crossing	Sept. 30	4.0	1.5	2.5	Very crooked channel.
Do	Oct. 7	3.5	2.0	1.5	
Cassville Slough (foot)	Aug. 17	4.5	2.5	2.0	Bad sticking point for many years.
Do	Oct. 9	5.0	2.6	2.4	Improved in 1879 and 1880.
Bellevue	July 22	10.5	6.9	3.6	Improved in 1878.
Sand Prairie	July 22	12.0	6.9	5.3	Good in 1880. Very bad for several years previous.
Do	Aug. 19	5.0	2.9	2.1	
Do	Sept. 27	7.0	3.7	3.3	
Arnold's	July 22	9.0	6.9	2.1	Bad obstruction.
Below Dark Slough	Aug. 19	5.5	2.2	3.3	Good for several years.
Do	Oct. 9	5.5	2.6	2.9	
Above Lyons	Aug. 19	5.3	2.2	3.1	Good for several years.
Do	Oct. 9	6.5	2.6	3.9	
Buffalo	Aug. 21	5.5	2.8	2.7	Tolerably good in 1880.
Rush Chute	Aug. 22	4.0	2.8	1.2	Very bad obstruction.
Burlington to Dalles	Aug. 21	4.0	2.8	1.2	Very bad obstruction, only 3 feet in lowest water of 1880.
Do	Sept. 6	6.0	3.5	2.5	
Montrose	Aug. 22	4.5	2.8	1.7	Bad for several years.
Gregory's Landing	Aug. 24	4.0	1.8	2.2	Bad obstruction.
Tully Island	Sept. 5	6.0	3.5	2.5	Good in 1880.
Smoot's Bar	Aug. 24	3.0	1.8	1.2	One of the worst obstructions below Keokuk; 3 feet in 1880.
Wyaconda	Aug. 24	4.0	1.8	2.2	Very bad in former years. Somewhat better in 1880.
Do	Sept. 5	6.5	3.5	3.0	
Quincy	Sept. 5	8.0	3.5	4.5	Improvement in 1879 by dams, &c.
Armstrong Island	Aug. 25	4.5	2.0	2.5	Good in 1880.
Do	Oct. 29	5.5	2.1	3.4	
Gilbert's Island	Aug. 27	4.0	2.0	2.0	Worst obstruction below Keokuk.
Do	Sept. 4	4.8	3.0	1.8	Now being improved by dams.
Do	Sept. 17	5.0	2.1	2.9	
Do	Oct. 21	4.0	2.4	1.6	
Do	Oct. 29	3.5	2.1	1.4	
Mundy's Landing	Aug. 28	6.0	2.0	4.0	Very bad in 1880.
Do	Sept. 4	6.0	3.0	3.0	
Do	Sept. 17	4.5	2.1	2.4	
Hickory Chute	Oct. 29	5.0	2.1	2.9	Good. (New channel.)
Krider's Bend	Aug. 28	5.5	2.0	3.5	Good in 1880. Very bad for some years previous.
Do	Sept. 3	7.5	3.0	4.5	
Slim Island	Aug. 28	6.5	2.0	4.5	Improved in 1879. Formerly the worst place below Keokuk.
Wesport Chute	Aug. 28	5.0	2.0	3.0	Very bad obstruction.
Dardenne Island	Sept. 2	5.0	2.0	3.0	Bad in 1880.

STATISTICS OF COMMERCE AND NAVIGATION.

Lumber.

The most important business interests on the Upper Mississippi and its principal tributaries is the lumber trade, giving employment to great numbers of men and upwards of 100 steamboats which are used in guiding and propelling rafts.

Between the mouth of the Chippewa and Saint Louis there are 75 mills on the main river with an annual day-sawing capacity of 650,000,000 feet, employing some 15,000 men and representing about $15,000,000 of capital.

On the Upper Mississippi and its tributaries, the Saint Croix, Chippewa, Wisconsin, and Black, there are about 200 mills engaged in the manufacture of lumber, the greater part of which product is floated into the former stream. The estimated product of white pine floated into the Mississippi River in 1880 was 2,000,000,000 feet; in 1879, 1,500,000,000 feet; in 1878, 900,000,000 feet; in 1877, 750,000,000 feet.

The following table shows the amount of lumber manufactured on the Upper Mississippi and tributaries in 1880, 1879, and 1878.

Table showing lumber business of Upper Mississippi and tributaries for 1880, 1879, *and* 1878.

Names, localities, &c.	Lumber manufactured.		
	1880.	1879.	1878.
	Feet.	*Feet.*	*Feet.*
W. D. Washburn & Co., Farnham & Lovejoy, Camp & Walker, and twenty other firms at Minneapolis and above	241, 657, 989	193, 688, 555	138, 913, 130
Laird, Norton & Co., W. & J. Fleming, Youman's Brothers, and nine other firms between Minneapolis and Dubuque	104, 060, 435	77, 629, 000	41, 300, 000
Ingram, Kennedy & Day, Dubuque Lumber Company, and three other firms at Dubuque	29, 450, 000	23, 750, 000	18, 725, 000
W. J. Young & Co., C. Lamb & Sons, and five other firms at Clinton, Lyons, and Fulton	144, 783, 202	120, 924, 000	63, 697, 915
Weyerhaeuser & Denkman, Dimock, Gould & Co., and eight other firms at Rock Island, Davenport, and Moline	162, 961, 000	115, 042, 000	56, 215, 000
Hershey Lumber Company, P. M. Musser & Co., and sixteen other firms below Davenport	213, 288, 000	106, 200, 000	51, 850, 553
Schulenberg, Boeckler & Co., Hersey, Bean & Brown, and twelve other firms on the Saint Croix	132, 475, 078	109, 000, 000	58, 520, 000
Eau Claire Lumber Company, Daniel Shaw & Co., and thirteen other firms on the Chippewa	361, 905, 370	260, 000, 000	128, 000, 000
John Paul, La Crosse Lumber Company, and eight firms on Black River	82, 000, 000	66, 165, 000	35, 202, 000
Mills unreported, say	50, 000, 000	50, 000, 000	.....
Total for Mississippi and tributaries, 116 firms ...	1, 522, 581, 074	1, 122, 398, 555	592, 423, 598

In addition to the above amount of lumber there were manufactured in 1880 about 500,000,000 shingles and 150,000,000 lath.

The product of the Wisconsin River is omitted from the above statement, inasmuch as nearly all the lumber made on that river is shipped by rail.

In order to show the entire lumber business of the Upper Mississippi Valley (omitting shingles, lath, &c.) for the past five seasons is given the following summary:

Summary.

Locality.	Lumber manufactured.				
	1880.	1879.	1878.	1877.	1876.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Main River	981, 139, 899	687, 233, 555	370, 701, 598	456, 840, 424	629, 967, 000
Saint Croix	132, 475, 078	109, 000, 000	58, 520, 000	53, 341, 030	66, 793, 000
Chippewa	361, 905, 370	260, 000, 000	128, 000, 000	157, 046, 678	255, 866, 999
Black	82, 000, 000	66, 165, 000	35, 202, 000	49, 250, 000	70, 852, 747
Wisconsin	175, 000, 000	152, 177, 025	193, 039, 314	143, 523, 000	154, 700, 000
Aggregate	1, 732, 520, 347	1, 274, 575, 580	785, 462, 912	860, 001, 132	1, 178, 179, 746

Receipts at Saint Louis from Upper Mississippi River.

	1880.	1879.	1878.
White pine lumber and logs.....feet..	229, 560, 917	179, 919, 115	129, 806, 733
Shingles.....pieces..	105, 246, 650	77, 811, 500	88, 057, 300
Lath.....do....	41, 028, 400	27, 713, 700	29, 441, 500

STEAMBOATS AND FREIGHT.

The principal steamboat lines on the Upper Mississippi River are the Keokuk Northern and Diamond Jo. There are also some independent boats carrying freight and passengers. The total amount of freight carried by these two lines was, in 1880, 567,180 tons; in 1879, 411,862 tons; in 1878, 430,000 tons. Being unable to obtain the requisite information, no estimate of amount of freight carried by the independent boats is given.

Statement of amount of freight received at and shipped from Saint Louis by the Upper Mississippi River for six years.

	1880.	1879.	1878.	1877.	1876.	1875.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Received	226, 095	221, 285	174, 065	136, 715	224, 860	198, 100
Shipped	55, 260	66, 990	67, 320	68, 565	93, 360	96, 225
Total carried	281, 355	288, 275	241, 385	205, 280	318, 220	294, 325

NOTE.—In addition to receipts of 1880 by boats, there were received 198,315 tons of lumber, logs, and shingles by rafts.

Receipts and shipments of leading articles at Saint Louis by Upper Mississippi River boats in 1880.

Articles.		Receipts.	Shipments.
Flour	barrels	53, 958	11, 505
Wheat	bushels	761, 323	19, 670
Corn	do	959, 717	369
Oats	do	1, 594, 169	2, 817
Rye	do	57, 937	270
Barley	do	153, 727	2, 315
Cotton	bales	.....	216
Pork	barrels	2, 543	233
Hams	pounds	107, 630	39, 275
Meats	do	1, 610, 545	43, 162
Lard	do	160, 720	78, 355
Cattle	head	7, 105	.....
Hogs	do	35, 824	.....
Sheep	do	6, 469	.....
Horses and mules	do	3, 706	.....
Hay	bales	103, 092	.....
Apples	barrels	43, 838	.....
Butter	pounds	55, 760	.....
Hides	do	280, 310	.....

The following table affords a comparative view of the relative amount of navigation at various localities on the Upper Mississippi River for the last three years:

Statement of steamers, barges, and rafts passing various bridges.

Locality of bridge.	Steamboats.			Barges.			Rafts.		
	1880.	1879.	1878.	1880.	1879.	1878.	1880.	1879.	1878.
Hastings	2, 065	2, 468	.....	448	397	.....	20	54	.....
Winona	4, 593	3, 760	2, 948	883	1, 362	1, 115	1, 392	1, 889	868
La Crosse	3, 539	2, 827	2, 095	505	779	842	1, 278	1, 077	594
Dubuque	3, 625	2, 894	2, 189	878	.....	884	1, 375	801	694
Clinton	3, 253	2, 643	1, 950	1, 020	996	913	*646	*590	*383
Rock Island	2, 664	2, 514	1, 643	642	750	613	782	571	352
Burlington	1, 871	1, 251	1, 318	694	662	624	522	367	254
Keokuk	1, 868	1, 562	1, 519	890	851	781	.....	.....	.....
Quincy	1, 831	1, 632	1, 450	616	815	524	349	269	191
Hannibal	1, 925	1, 586	1, 393	760	549	549	237	260	156
Louisiana	1, 459	1, 856	1, 390	705	545	545	110	120	89

*Partial record.

CUSTOMS, REVENUE, AND TONNAGE FOR FISCAL YEAR ENDING JUNE 30, 1880.

That portion of the Mississippi River between Saint Paul and the mouth of the Illinois River lies partly in the customs district of Minnesota and partly in the district of New Orleans. Surveyors of customs are located at Burlington and Dubuque, Iowa; Galena, Ill.; Saint Paul, Minn., and La Crosse, Wis.

In the following statement is given the *total* exhibit of the port of Saint Louis, where the greater part of the Upper Mississippi boats are registered, and which includes many of the Lower Mississippi, Missouri, and Illinois River boats.

Port.	Collections.	Enrolled tonnage.	Vessels.
Saint Louis	$1,173,587	141,974	319
Burlington	73	2,414	30
Dubuque	220	3,987	36
La Crosse	None.	6,227	40
Galena	5,365	2,332	26
Saint Paul	16,793	3,931	31

INTERNAL REVENUE.

There are ten internal-revenue districts bordering on the Mississippi River between Saint Paul and the mouth of the Illinois River. Each of these districts is composed of a large number of counties, the greater portion of which do not touch the river, but the bulk of the revenue to the government comes from the sections bordering on the river and tributary to its navigation and commerce. I give below a table showing the designation of the districts touching the river between the points above named, the residence of the collector, and the amount of collections for the fiscal year ending June 30, 1880.

District.	Residence of collector.	Amount collected for year ending June 30, 1880.
First Minnesota	Rochester	$107,389 53
Second Minnesota	Saint Paul	257,300 11
Second Wisconsin	Madison	155,505 99
Sixth Wisconsin	Sparta	116,083 43
Second Iowa	Davenport	303,114 74
Third Iowa	Dubuque	267,818 99
Fourth Iowa	Burlington	165,050 34
Third Illinois	Mount Carroll	175,920 91
Fourth Illinois	Quincy	983,112 88
Fourth Missouri	Louisiana	260,484 63
Aggregate		2,791,781 55

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 2.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM SAINT PAUL TO DES MOINES RAPIDS.

As heretofore, under this appropriation, works have been carried on for the improvement of through navigation, consisting in closing and spur dams, and shore protections of brush and stone.

The appended reports of United States Civil Engineer M. Meigs and

Assistant Engineers E. F. Hoffman and J. L. Gillespie give in detail the work done and results obtained in their respective districts. To these gentlemen much credit is due for the manner in which they have performed their duties.

Improvements were carried on during the past year by contract at Red Wing, Wabasha, Fountain City, Winona, Horse Island, and Keithsburg, and by day's labor at Nininger Slough, Beef Slough, Pomme de Terre Slough, Cassville, Guttenberg, Rush Chute, and Shokokon Slough.

Owing to the extreme high stage of the river during summer of 1880, and the lateness of the passage of the river and harbor bill, most of the above work did not commence until September, and all work was suspended quite early on account of the freezing of the river, but in the short time available for work much was accomplished.

Since the opening of navigation this spring the river has remained high, and no special examinations have therefore been made of the improved localities since the completion of the works, but from the changes which commenced to take place while construction was going on, and general examinations since, it can be stated that the same good results were obtained as in former years. The portions of the channel improved previous to last season have continued during the past year to grow better, and the results have shown that the system being followed will, in time, accomplish all that is expected of it.

During the past season as much of the work as could be laid out sufficiently in advance was done by contract; but as much of the work must necessarily be done by day's labor, four complete plants, consisting each of one tow-boat and nine barges are being procured, and will be available for the present season's work. With these plants and the large quantities of stone and brush being collected in advance, a much greater amount of work can be accomplished than under the system heretofore followed. The act of Congress of March 3, 1879, provided that $20,000 might be used for testing the "Adams Flume," and the bar below Read's Landing was selected for the experimental work. Mr. Adams has as yet done nothing towards putting his invention to a practical test, and as the bar heretofore reserved has become, through the removal of others, the most troublesome obstruction below Lake Pepin, the work laid out for this season contemplates its improvement.

The necessity for owning and operating a dredge on this section of the river has been very apparent during the past year, and it is hoped arrangements can be made for constructing one during the coming winter. The work of the present season has been commenced, but as yet little has been accomplished owing to continued high stage of water. Contracts have been let for constructing dams, &c., near Wabasha, and between Fountain City and Winona. Work will be carried on by day's labor at such other points as the coming low-water may show to be most in need of improvement.

Much of this work will be done between Saint Paul and Hastings, and it is expected to use two of the government plants and expend $50,000 on this stretch of the river.

Experiments in willow planting are being made, and successful results are hoped for, as the lack of this material will soon be severely felt.

The appropriation for the snag-boat General Barnard being insufficient, an allotment of $5,000, was made from this appropriation to assist in keeping her in commission during the season, and much assistance was rendered by her in works of improvement as well as in making surveys and examinations.

As sketches showing the general features of the work have been published in previous reports and as no examinations sufficient in detail to show accurately the present condition of improved channel have been made, no maps are presented with this report.

As the government will hereafter be fully provided with well-appointed plants, capable of doing much more work than could be heretofore attempted, and as large appropriations will secure more economical work and much earlier benefits than can be expected from such amounts as have been heretofore available, I would respectfully ask for an appropriation of $750,000 for the fiscal year ending June 30, 1883. Even this amount is comparatively small when the great number of points to be improved and the 500 miles of the district are considered.

SUMMARY OF EXPENDITURES FOR FISCAL YEAR ENDING JUNE 30, 1881.

Nininger Slough (Island No. 17)	$470 67
Red Wing	9,106 32
Wabasha	13,663 86
Beef Slough	26,112 58
Pomme de Terre Slough	6,068 56
Fountain City (Rollingstone)	8,951 76
Winona	15,700 84
Cassville	13,850 96
Guttenberg	3,186 33
Horse Island	1,085 68
Keithsburg	6,649 49
Rush Chute	813 64
Shokokon Slough	3,999 65
Purchase of plants	12,324 54
Surveys	2,585 36
Snag-boat	4,399 06
Total expended	128,969 30

NOTE.—Of the above amount, the sum of $214.18 was reported as outstanding liabilities in last annual report:

ABSTRACT OF APPROPRIATIONS.

By act approved June 18, 1878	$250,000 00
By act approved March 3, 1879	*100,000 00
By act approved June 14, 1880	150,000 00
By act approved March 3, 1881	200,000 00
	700,000 00

Money statement.

July 1, 1880, amount available	$173,600 05	
Received from sale of fuel	18 66	
Amount appropriated by act approved March 3, 1881	200,000 00	
		$373,618 71
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	128,755 12	
July 1, 1881, outstanding liabilities	754 91	
		129,510 03
July 1, 1881, amount available		244,108 68
Amount that can be profitably expended in fiscal year ending June 30, 1883		750,000 00

*$20,000 set aside for testing the "Adams Flume."

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for construction of a brush and stone dam and shore protection above Red Wing, Minn.*

Number.	Names and residences of bidders.	3,500 cubic yards for brush.*		4,500 cubic yards.†		Aggregate.
		Per cubic yrad.	Amount.	Per cubic yard.	Amount.	
1	Edgar Folson, Minneapolis, Minn	$1 00	$3,500 00	$1 75	$7,875 00	$11,375 00
2	John J. Palmer, Indianapolis, Ind	1 03	3,605 00	1 43	6,435 00	10,040 00
3	Sid. J. Truax, Hastings, Minn	0 90	3,150 00	1 14	5,130 00	‡8,280 00
4	P. S. Davidson, La Crosse, Wis	1 15	4,025 00	1 50	6,750 00	10,775 00

* Including all the labor and material necessary fo furnishing, making into mats, putting in place, and securing.
†For stone, placed as specified.
‡Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for constructing a brush and stone dam and shore protection three miles below Wabasha.*

Number.	Names and residences of bidders.	5,000 cubic yards brush.		4,500 cubic yards stone.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Jacob Richtman, Fountain City, Wis	$0 90	$4,500 00	$1 40	$6,300 00	$10,800 00
2	John J. Palmer, Indianapolis, Ind	0 95	4,750 00	1 53	6,885 00	11,635 00
3	Sid. J. Truax, Hastings, Minn	0 90	4,500 00	1 39	6,255 00	*10,755 00
4	P. S. Davidson, La Crosse, Wis	1 25	6,250 00	1 60	7,200 00	13,450 00

*Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for constructing dams and shore protections of brush and stone near Fountain City, Wis.*

Number.	Names and residences of bidders.	6,000 cubic yards stone.		5,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Jacob Richtman, Fountain City, Wis	$1 30	$7,800 00	$0 80	$4,000 00	*$11,800 00
2	John J. Palmer, Indianapolis, Ind	1 46	8,760 00	0 90	4,500 00	13,260 00
3	P. S. Davidson, La Crosse, Wis	1 60	9,600 00	1 25	6,250 00	15,850 00
4	Edgar Folsom, Minneapolis, Minn	1 40	8,400 00	1 20	6,000 00	14,400 00

*Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for constructing dams and shoal protections of brush and stone at the bar above Winona, Minn.*

Number.	Names and residences of bidders.	5,000 cubic yards brush.		6,000 cubic yards stone.		Aggregat .
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	John J. Palmer, Indianapolis, Ind	$1 03	$5,150 00	$1 60	$9,600 00	$14,750 00
2	Jacob Richtman, Fountain City, Wis	0 86	4,000 00	1 30	7,800 00	*11,800 00
3	P. S. Davidson, La Crosse, Wis	1 25	6,250 00	1 70	10,200 00	16,450 00

*Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for dredging in the Mississippi River, one mile below Keithsburg, Ill.*

Number.	Names and residences of bidders.	Dredging.	Aggregate.
		Per cu. yd.	
1	H. S. Brown, Hamilton, Ill	$1 10	$1 10
2	A. J. Whitney & Son, Keokuk, Iowa	98	*98

*Contract awarded.

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m. May 20, 1881, *for constructing brush and stone dams and shore protection between Reed's Landing and Wabasha, Minn.*

Number.	Names of bidders.	Residences.	10,000 cubic yards stone.		10,000 cubic yards brush.		Aggregate.
			Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	John Gage	Weaver, Minn	$1 60	$16,000 00	$1 15	$11,500 00	$27,500 00
2	Sid. J. Truax	Hastings, Minn	1 59	15,900 00	1 10	11,000 00	*26,900 00
3	M. W. McDonald	Alma, Wis	1 52	15,200 00	1 42	14,200 00	29,400 00

*Contract awarded.

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m., May 20, 1881, *for constructing brush and stone dams and shore protections above Winona, Min.*

Number.	Name of Bidder.	Residence.	12,000 cubic yards stone.		2,000 cubic yards brush.		Aggregate.
			Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Jacob Richtman	Fountain City, Wis.	$1 40	$16,800 00	$0 90	$10,800 00	*$27,600 00

*Contract awarded.

REPORT OF MR. J. L. GILLESPIE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 1, 1881.

SIR: I have the honor to submit the following report of operations for the improvement of the Mississippi River from Saint Paul to Chimney Rock, from July 1, 1880, to January 1, 1881.

NININGER SLOUGH (ISLAND No. 17).

A dam of rock was built across the head of the chute in 1875 by the snag-boat Montana, and had an excellent effect for several years. The high-water of June, 1880, opened a gap between this dam (No. 1) and the head of Island 17, which had been insufficiently protected. This break was repaired at a cost of $470.67. The whole dam will be raised about 3 feet during the coming season.

RED WING.

The work at this place consisted in building a closing dam (No. 1) near the head of the north or Wisconsin channel, and protecting the shore of Island 24. The work was done under contract with Mr. S. J. Truax, dated August 21, 1880; Mr. C. L. Williams, inspector.

The contract prices were, for stone, $1.14, for brush, 90 cents per cubic yard. Work was commenced September 1, and finished October 20, 1880. Dimensions of dam are as follows: length, 638 feet; base, 32 feet; average height, 6½ feet, or 4 feet above low-water of 1864. The shore protection is 2,075 feet in length, including a dam across a small slough 72 feet long and 28 feet wide, three courses of brush high. For about 1,400 feet from the lower end mats 20 feet square were sunk below the water-line and the protection carried up the bank to about 6 feet above low-water. Above this point the water was shoaler and mats from 8 to 12 feet wide were used, the bank being covered to the same height as below. The covering of stone was about 10 inches thick. This work is preliminary to the improvement of the channel at the head of Lake Pepin.

Materials used and cost of work.

Description.	Linear feet.	Stone at $1.14 per cubic yard.	Brush at 90 cents per cubic yard.	Amount.
		Cub. yds.	*Cub. yds.*	
Dam No. 1 (sheet 10*)	638	1,564.23	1,343.70	$2,992 88
Shore protection (sheet 10)	2,075	2,184.72	2,757.87	4,972 66
	.....	3,748.95	4,101.57	7,965 54
Superintendence and office expenses	.....	.....	.....	1,140 78
Total	.....	.....	.....	9,106 32

* The sheets referred to are the general maps of survey, Saint Paul, Minn., to Grafton, Ill.

BELOW WABASHA.

The works in this vicinity included the building of two spur dams (Nos. 9 and 10) from the right bank between Crat's Island and Te-pee-ota Point, a closing dam (No. 11) across the small slough above the mouth of the Zumbro River, and shore protection on left bank opposite the lower spur. The inspectors were Mr. A. J. Stibolt, from September 13 to October 25, and Mr. C. L. Williams from the latter date to the close of the work, November 17. The contract price for stone was $1.39 per cubic yard, for brush 90 cents. This work is in continuation of that commenced at Crat's Island in 1878, and is designed to confine the low-water flow of the river to a channel about 900 feet wide along the left bank.

A detailed survey of the river was made from the foot of Lake Pepin to Te-pee-ota Point, and would have been extended to Alma, but the work was interrupted by running ice.

Materials used and cost of work.

Description.	Linear feet.	Stone at $1.39 per cubic yard.	Brush at 90 cents per cubic yard.	Amount.
		Cub. yds.	*Cub. yds.*	
Closing dam No. 11 (sheet 14)	300	424.72	717.64	$1,236 24
Shore protection opposite dam 10	737	550.51	670.98	1,369 09
Dam No. 10 (sheet 14)	1,450	1,920.42	2,232.22	4,678 38
Dam No. 9 (sheet 14)	1,000	1,909.43	2,399.03	4,813 23
	.....	4,805.08	6,019.87	12,096 94
Superintendence and office expenses	.....	.....	.....	1,566 92
Total	.....	.....	.....	13,663 86

BEEF SLOUGH BARS.

The works constructed in this reach of river consisted of closing dams from the right bank to Island 36 (No. 14), between Islands 36 and 37 (No. 15), and between Islands 37 and 39 (No. 16), two spur dams (12 and 13) from the right bank above Island 36; shore protections on the left bank at exposed points and also on the heads of the islands above named and at foot of Island 39; and a closing dam at the head of West Newton Slough (No. 17).

The object of the works was to confine the low-water discharge to a channel about 900 feet wide, along the left bank, in continuation of the improved channel above. The dams were built to a height of about 4 feet above low-water, and are composed of mats made of fascines 12 feet in length, loaded with stone in the usual manner.

The work was performed by hired labor, the materials being purchased in open market.

Materials used and cost of work.

Description.	Lin. ft.	Stone.	Brush.	Amount.
		Cub. yds.	*Cub. yds.*	
Dam No. 14 (sheet 14)	1,020	1,183.46	1,033.46	$3,552 68
Dam No. 15 (sheet 14)	380	568.82	394.05	1,177 08
Dam No. 16 (sheet 14)	1,120	1,368.71	1,034.09	2,934 49
Dam No. 12 (sheet 14)	1,100	1,210.91	1,507.48	3,319 76
Dam No. 13 (sheet 14)	1,050	2,008.61	2,157.87	5,090 03
Dam No. 17 (sheet 14)	320	618.11	657.68	1,557 09
Shore protections (sheet 14)	4,347	3,137.31	2,494.37	6,877 49
	.....	10,795.93	9,279.00	24,508 62
Contingencies and office expenses and superintendence	.....	.....	.....	1,603 96
Total	.....	.....	.....	26,112 58

POMME DE TERRE SLOUGH.

The head of the slough was closed by two dams, the first from Island 45 to tow-head (No. 1) and the second from tow-head to Island 46 (No 2). The upper end of Island 46 was protected for a distance of 1,200 feet.

Work was commenced on a closing dam across a small cut-off from the main river to West Newton Chute, opposite the foot of Pine Island, formed by the high-water of June, 1880, but only one layer of material was put in before the work was stopped by ice. The work was done by the same outfit and in the same manner as that at Beef Slough bars. The dams were built to a height of about 4 feet above low-water. Dam No. 2 will require some additional stone, as the work was interrupted by ice before entire completion.

The shore protection consists of mats about 20 feet square, sunk at the foot of the bank and loaded with stone above, which is a revetment of loose brush and stone, to a height of 6 feet above low-water. The lower 300 feet of the shore protection was not completed above the water-line.

Materials used and cost of work.

Description.	Linear feet.	Stone.	Brush.	Amount.
		Cub. yds.	*Cub. yds.*	
Dam No. 1 (Sheet 15)	200	286.76	256.21	$638 50
Dam No. 2 (Sheet 15)	750	1,312.71	1,173.45	2,926 05
Shore protection (Sheet 15)	1,200	675.63	807.06	1,749 41
Cut-off Dam	70	65.23	243.44	363 34
	.....	2,340.33	2,480.16	5,677 30
Superintendence and office expenses	.....	.....	.....	391 26
Total	.....	.....	.....	6,068 56

Very respectfully, your obedient servant,

J. L. GILLESPIE,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
ROCK ISLAND, ILL., *January* 1, 1880.

SIR: I have the honor to present the following report of works for the improvement of the Mississippi River between Chimney Rock Bar and Le Claire, Iowa, during the past season.

ROLLINGSTONE BAR.

The work of improving this bar was continued under contract with Jacob Richtman of Fountain City, Wis. The inspectors were Mr. James P. Allen assisted by Mr. Matthias Little until October 26, 1880; after that time Mr. Allen was relieved by Mr. C. M. Bennett. Work began September 7 and was continued to the close of navigation, November 16. The closing dam at Rollingstone was repaired and work begun on the extension of Dam No. 1. A dam (No. 3) 708 feet long was built from the Wisconsin

shore opposite Island 56 and 800 feet of shore protection put on the Wisconsin shore extending down stream from that put on in 1879. The gap in the closing dam (*a*) was raised to low-water line, considerable material being required, mostly rock, as in the places where it had settled most the depth of water on the dam had increased from 1½ feet at low-water to from 4 to 16 feet, and the current was too strong to permit the use of much brush, the mattresses being torn in pieces under the strain while being sunk. Dam No. 3 was built to a grade of 4 feet above low-water rising somewhat toward the shore.

It is hoped that this dam will deepen the channel at the head of Rollingstone on a crossing that has continued bad during the last three seasons. The work on dam No. 1 was limited to raising the old dam, which was not built originally higher than 4 feet below low-water. The early close of navigation prevented the extension of the dam as planned.

The improvement of Rollingstone bars cannot as yet be considered completed, as the channel is changing slowly and should be followed up and fixed when it has reached a shape that it seems advisable to retain and make permanent. It may be said, however, that this bad section of the river has been so improved that there are much worse bars both above and below which furnish the ruling depths for navigation, and the results of the works so far executed can be considered successful.

Materials used and cost of work.

Description.	Linear feet.	Rock at $1.30 per cubic yard.	Brush at 80 cents per cubic yard.	Amount.
		Cub. yds.	*Cub. yds.*	
Shore Protection (Sheet 17)	800	952.12	745.05	$1,833 80
Dam No. 3 (Sheet 17	708	1,760.33	648.74	2,807 42
Closing Dam (a) (Sheet 17)	Repairs.	1,474.97	470.30	2,293 70
Dam No. 1 (Sheet 17)	Repairs.	357.08	267.70	678 36
		4,544.50	2,131.79	7,613 28
Superintendence and office expenses				1,338 48
Total				8,951 76

Average cost per yard, including contingencies, $1.34.

WINONA BAR.

This work was also let to Mr. Jacob Richtman, of Fountain City, Wis., August 23, 1880. The inspector was Mr. James P. Allen, to October 26, when he was relieved by Mr. C. M. Bennett. The work consisted in closing two sloughs back of Island 69 by dams Nos. 1 and 2, built to a grade of 4 feet above low-water; also the construction of two dams, Nos. 17 and 18, from the right bank of the river, one dam, No. 19, from Island 72, for the contraction of the water-way across Winona bar; 700 feet of riprap at the head of Island 72, and some repairs to dam No. 20. Dam No. 18 was not completed, the unusually early close of navigation preventing the finishing of these works and the completion of a survey of the bar, which it was intended to make. The works constructed in 1879 were found to have stood remarkably well, with the exception of dam No. 20. This dam, built in very shoal water, and consisting of but a single course of brush and rock, was, by the change of direction in the channel, exposed to a powerful pressure and settled in places 2 feet. It was brought up to grade 4 feet above low-water by the expenditure of about 600 cubic yards of rock. Immediately above dam 20 the shore of Island 71 showed signs of giving way under the increased scour of the current, and will probably need 600 to 800 feet of shore protection.

Materials used and cost of work.

Description.	Linear feet.	Rock at $1.30 per cubic yard.	Brush at 80 cents per cubic yard.	Amount.
		Cubic yards.	*Cubic yards.*	
Dam No. 1 (sheet 18)	180	814.4	361.5	$1,347 92
Dam No. 2 (sheet 18)	125	230.3	165.9	432 11
Dam No. 17 (sheet 18)	600	1,596.7	867.2	2,769 47
Dam No. 18 (sheet 18)	1,480	1,824.6	1,549,0	3,611 18
Dam No. 19 (sheet 18)	650	1,738.9	1,055.6	3,105 05
Dam No. 20 (sheet 18)		597.5		776 75
Shore protection, Island 72	700	674.2	472.3	1,254 30
		7,476.6	4,471.5	13,296 78
Superintendence and office expenses				2 404 06
Total				15,700 84

Average cost per yard, including contingencies, $1.31.

An examination of the Winona Bar made in August before beginning the season's work of construction showed a marked tendency toward cutting away the bar below the head of Island 72 and going down along the shore of this island. Dam No. 19 was put in to prevent this change.

Steamers had but little detention on the Winona Bar during the season of 1880, and the 3-foot channel almost doubled in width, while the 4½-foot channel was extended greatly. The river is changing to the left of Argo Island and will need to be confined to a definite channel as well as prevented from moving the great sand-bar above Island 71 down upon and among our works.

CASSVILLE SLOUGH.

This work was done by days' labor and purchase in open market. Mr. C. M. Bennett was overseer in charge, and performed his duties with intelligence and fidelity. The work consisted in extending the shore protection opposite Island, 192 to the foot of "Twelve-mile Island" the effect of last year's closing of the slough to the left of Island 192 being shown by a rapid scour along the whole right bank of the channel below the old shore protection. There were also constructed two spur dikes (Nos. 2 and 3) from the shore of Island 192 for contracting the water-way across the bar at the foot of Cassville Slough. The shore protection was of much lighter construction than that used in previous seasons, especially in the quantity of rock used, and it is hoped will prove permanent enough to warrant our using similar light constructions in the future. The riprap is carried from 4 to 6 feet above low-water, and it is intended to plant the upper portion of the slopes with willow cuttings.* Rock was purchased of Kelleher & Petersen at 75 cents per cubic yard, loaded on the scows, and was towed from Glen Haven to the works. The brush was mostly cut by hired labor, although some of it was purchased. It was taken from public lands 2 to 5 miles below Cassville and no royalties paid. The dams were built 4 feet above low-water, and before the close of navigation had produced a marked and beneficial effect on the channel across the bar. After the completion of the work at foot of Cassville Slough it was deemed advisable to put a little shore protection on the head of Island 195, one mile below Cassville. The head of the island was caving rapidly, and the river shows an inclination to forsake the good channel along the bluff and go to the left of Island 195, which would be a misfortune, and should be averted if possible. As a preliminary step the head of the island was secured, and it is proposed to plant with willows the high bar which is crowding the water-way from the present channel and hold it, if possible, where it now is. As the work at head of Island 195 and that at Cassville Slough were done together the estimates of cost, &c., are not separated.

Materials used and cost of work.

Description.	Linear feet.	Rock.	Brush.	Amount.
		Cubic yds.	*Cubic yds.*	
Shore protection, Island 189	1,900	1,705.34	1,908.64	$4,615 89
Dam No. 2 (sheet 33)	355	1,792.17	993.62	3,557 81
Dam No. 3 (sheet 33)	625	1,182.02	1,200.92	3,040 16
Shore protection, Island 195	500	597.42	497.56	1,395 34
	.....	5,276.95	4,600.74	12,609 20
Superintendence and office expenses	.....	.....	.....	1,241 76
Total	.....	.....	.....	13,850 96

Average cost per yard, including contingencies, $1.40.

GUTTENBERG.

At the request of citizens of Guttenberg, and by authority of the Secretary of War, the allotment from the general appropriation for improving Mississippi River for "Dredging in Guttenberg Channel" was expended in building a dam across Swift Slough. This slough behind an island opposite Guttenberg diverts so much water as to cause a bad bar just above the town, which is the main impediment to navigation at that point. The work was begun November 4 and was prosecuted under considerable difficulties until the close of navigation November 16. The dam, 392 feet long, has the bottom layer of brush and rock extended about 200 feet from one shore, and about 100 feet from the other, leaving a gap of about 90 feet in the middle without

*Since writing the above, some experiments in willow planting have been made in the vicinity of Cassville, the results of which will be given later.

any brush or rock. The shore protections were completed on both shores 130 feet long, well loaded with rock. The banks on both sides of the slough are high, and required a wide shore protection. The grading was difficult and expensive, owing to the great number of large trees which had to be felled and the stumps grubbed out at a great cost for labor. The amount of material put in the work was, rock 560.16, brush 305.53 cubic yards.

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

REPORT OF MR. E. F. HOFFMANN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1881.

SIR: I have the honor to submit my annual report of operations for improvement of Mississippi River, between Rock Island and Des Moines Rapids, for the fiscal year ending June 30, 1881.

HORSE ISLAND.

Between September 24 and October 6, 1880, the remainder of the rock chiseled in 1879, and lying in the channel at this point, was removed by dredge.

COST OF WORK.

367.51 cubic yards rock removed, at $2.50	$918 77
Superintendence and officeexpenses	166 91
Total	1,085 68

No further improvement at this locality is required.

KEITHSBURG.

An allotment from the general appropriation for the improvement of Mississippi River, Saint Paul to Des Moines Rapids, amounting to $10,000, was set aside for continuing the dredging at the bar near Keithsburg. A survey was made in August, 1880, to ascertain the action of the high-water of 1880 upon the cut made in the fall of 1879 and spring of 1880. The cut was found to be filled up to a very considerable extent with sand. It was then determined, after careful observations of the current, to adopt a plan of work connecting directly the deep water on one side of the bar with the deep water on the other. Dredging was begun October 6, under contract with Whitney & Son, and continued until November 16, 1880, when ice in the river put a stop to further operations. A cut was made 650 feet in length, by 120 feet in width, through a tenacious stratum of clay mixed with bowlders and heavy gravel.

During the winter a survey was made showing that the cut made in the fall remained in good condition.

COST OF WORK.

6,215.43 cubic yards material removed, at 90 cents	$5,593 89
Superintendence and office expenses	1,055 60
Total	6,649 49

RUSH CHUTE.

An allotment of $5,000 was made from the general appropriation to assist in completing the work at this locality. A report of operations will be found under head of "Improving Harbor at Burlington, Iowa."

SHOKOKON SLOUGH.

An allotment of $12,000 for work at this point was set aside for closing Shokokon Slough. Up to the present time no work has been done other than collection of materials and driving a line of piling across the chute.

Very respectfully, your obedient servant,

E. F. HOFFMANN,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 3.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM DES MOINES RAPIDS TO MOUTH OF THE ILLINOIS RIVER.

With this appropriation, works for the improvement of through navigation are carried on, the points selected each year for inaugurating new works being those at which the most serious obstructions are found. These points are less in number, but the work required at each separate point much greater in amount than on the river above Des Moines Rapids. Improvements at but a few points can, therefore, be carried on at once with the limited appropriations available.

My project for the expenditure of $100,000 appropriated by act approved June 14, 1880, contemplated a continuation of the work at Gilbert's Island, the inauguration of works at Gregory's Landing and Westport Chute, and the completion of the Denmark Island Dam, all the work except the first mentioned to be done by contract. During the fall of 1880 the continued high-water and early close of navigation seriously interfered with operations, and comparatively little was done by the contractors. Difficulty in obtaining boats, barges, and material also greatly delayed the work at Gilbert's Island. Work at all points except Gregory's Landing was resumed this spring and the improvements at Denmark Island and Westport Chute were completed to as great an extent as funds permitted early in the season.

GILBERT'S ISLAND.

The work accomplished at this locality during the fall of 1880 is fully detailed in the appended report of Assistant Engineer O. N. Chaffee, who has been in immediate charge during the year, and to whom much credit is due for its successful prosecution under many difficulties. Arrangements for the rapid delivery of 30,000 cubic yards of rock were made during the winter, and since the opening of navigation the work of raising the closing dam in Gilbert's Chute, the spur-dam extending from the foot of Gilbert's Island, and the Denmark Island Dam has been vigorously carried on. It is intended to raise them to a height of 10 feet above low-water, and preserve them as far as possible from the injurious effects of ice.

During the early part of the season a tow-boat and barges were hired, but this plant has recently been replaced by a tow-boat and barges purchased by the government, and if the supply of material can be kept up as heretofore, more rapid progress will be made on this work during the present season than ever before.

During the year 24,050 cubic yards of rock, 3,857 cubic yards of gravel, and 3,063 cubic yards of brush were put in the dams at a cost, including superintendence and office expenses, of $36,361.23.

GREGORY'S LANDING.

Just above Gregory's Landing the channel for several years had been to the left of a small tow-head and much obstructed by rocks. In 1880, a channel being found on the right side of the tow-head, it was determined to keep it there by closing the former channel. Under contract with Whitney & Son, work was commenced October 15 and continued until stopped by ice November 17. High-water has as yet prevented

the resumption of work this season. The work accomplished consisted in the commencement of a dam from the tow-head to Hackley's Island and the protection of the ends of the dam, about one-half of the proposed amount being performed.

SUMMARY OF WORK AND COST OF SAME.

3,054.43 cubic yards of rock in place, at $1.15	$4,734 37
3,242.60 cubic yards brush in place, at 90 cents	2,918 34
	7,652 71
Less 10 per cent. retained	765 27
Amount paid contractors	6,887 44
Superintendence and office expenses	1,371 14
Total paid during the year	8,258 58

WESTPORT CHUTE.

This having been for a number of years a very troublesome locality, its improvement was considered advisable, and work was commenced under contract with C. M. Cole, of Marietta, Ohio, September 10, 1880, and suspended November 16; resumed April 2, 1881, and completed May 18. As the channel in this vicinity was much better than usual last season, a portion of the amount originally allotted to this work was used to much better advantage at other points. The work done consisted in a closing dam behind Kickapoo Island and protection of the head of the island, and closing dams between Islands 489 and 490, 490 and 490½, 490½ and 491. There were used in the work 7,985.83 cubic yards of rock and 5,743.31 cubic yards of brush, at a cost, including superintendence and office expenses, of $13,786.30.

DENMARK ISLAND.

Denmark Island Dam was begun in 1879, and the contract for its completion was awarded to C. M. Cole. During the year, 4,407.47 cubic yards of rock were put in by the contractor, at a cost, including superintendence and office expenses, of $6,528.70.

With the funds now available, work at Gilbert's Island will be continued, the Canton and Smoot's Chute dams built in 1879 will be raised and strengthened, and such new work will be commenced as the next low-water season may show to be advisable. As the greater portion of the work in the future must be done by days' labor, material being purchased in advance at convenient points either by regular contract or informal agreements, it is probable a second plant will be required during the coming fiscal year for prompt and effective work.

The number of dredges available on this section of the river being inadequate, it is desirable that the government should own and operate one, and it is hoped that a dredge can be built during the coming winter.

The appropriation for operating the snag-boat being insufficient, an allotment was made from this appropriation.

As large appropriations can be expended more economically and to better advantage than small ones, and as by reducing the time required for completion of work commerce will be sooner benefited, I would respectfully suggest an appropriation of $500,000 for fiscal year ending June 30, 1883.

SUMMARY OF EXPENDITURES FOR FISCAL YEAR ENDING JUNE 30, 1881.

Gregory's Landing	$8,258 58
Denmark Island	6,528 70
Westport Chute	13,786 30
Gilbert's Island	36,361 23
Purchase of plant	20,301 91
Surveys and gauge readers	543 55
Snag-boat	6,852 11
	92,632 38

ABSTRACT OF APPROPRIATIONS.

By act approved June 18, 1878	$100,000
By act approved March 3, 1879	40,000
By act approved June 14, 1880	100,000
By act approved March 3, 1881	175,000
	415,000

Money statement.

July 1, 1880, amount available	$102,545 48	
Received from sale of fuel	70 14	
Amount appropriated by act approved March 3, 1881	175,000 00	
		$277,615 62
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	92,632 38	
July 1, 1881, outstanding liabilities	765 27	
		93,397 65
July 1, 1881, amount available		184,217 97
Amount that can be profitably expended in fiscal year ending June 30, 1883		500,000 00

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for construction of dam and shore protections of brush and stone at bar above Gregory's Landing, Missouri.*

Number.	Names and residences of bidders.	8,000 cubic yards stone.		5,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Whitney & Son, Keokuk, Iowa	$1 55	$12,400 00	$0 90	$4,500 00	*$16,900 00
2	W. A. & J. C. Patterson, Keokuk, Iowa	1 55	12,400 00	0 94	4,700 00	17,100 00
3	Fruin & Co., Saint Louis, Mo	1 57	12,560 00	1 00	5,000 00	17,560 00
4	James McNamara, Keokuk, Iowa	1 70	13,600 00	0 95	4,750 00	18,350 00

*Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for completion of a stone dam near Denmark Island.*

Number.	Names and residences of bidders.	5,000 cubic yards stone.		Aggregate.
		Per cubic yard.	Amount.	
1	C. M. Cole, Marietta, Ohio	$1 15	$5,750 00	*$5,750 00
2	H. S. Brown, Hamilton, Ill	1 63	8,150 00	8,150 00

*Contract awarded.

Abstract of proposals received and opened, August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for construction of dams and shore protections of brush and stone at Westport Chute.*

Number.	Names and residences of bidderss.	11,500 cubic yards stone.		9,500 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	H. S. Brown, Hamilton, Ill.....	$1 50	$17, 250 00	$0 95	$9, 025 00	$26, 275 00
2	Whitney & Son, Keokuk, Iowa.....	1 50	17, 250 00	0 90	8, 550 00	25, 800 00
3	C. M. Cole, Marietta, Ohio	1 10	12, 650 00	0 60	5, 700 00	*18, 350 00
4	Fruin & Co., Saint Louis, Mo	1 44	16. 560 00	0 88	8, 360 00	24, 920 00
5	James McNamara, Keokuk, Iowa.....	1 90	21, 850 00	1 25	11, 875 00	33, 725 00

*Contract awarded.

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REPORT OF O. N. CHAFFEE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., February 15, 1881.

SIR: I have the honor to present the following report of the progress of work in the vicinity of Gilbert's Island during season of 1880.

A brief recapitulation of the circumstances which have transpired, is necessary to a fair understanding of the work at this point.

During the winter of 1879–'80; the channel along the Illinois shore through to deep water opposite the foot of Little Slim Island, had improved so much, as demonstrated by the survey made in March, 1880, that it was decided to remove a portion of Dam No. 3, and accordingly 450 feet of the shore end was taken out. Instead of giving any increased depth of water as was expected, the channel partially filled up below, and the current made a short turn across the river under the remainder of the dam and cut a new channel through the shoal to the shore of Gilbert's Island, having about an equal depth of 3½ feet to that below. The old crossing above this dam was entirely filled up down to the head of the dam so as to be out of water the greater part of the distance at "low water."

The dam across Gilbert Chute was found to have settled so that there was about 4 feet depth of water, going over a considerable part of it at a stage of 2 feet. The channel around by Cincinnati became so bad that boats ceased running there and passed by way of the chute from the middle of October till the end of the season.

Authority having been obtained to do the work by hired labor, operations were begun there on the 28th of August, by a foreman and several men beginning the collection of piles and brush.

The first work decided to be built was a wing-dam from the foot of Gilbert's Island, across the deep-water channel next to the island, to the shoal in the middle of the river.

Instead of proceeding in the usual way, two rows of piles 20 feet apart were driven 10 feet apart along the line of the dam, between which brush was placed in three layers alternately in the direction of the dam and at right angles to it, and then sunk with rock. A sufficient quantity having been placed on it, a third row of piles was driven 20 feet farther up stream, 20 feet apart on the row, and materials sunk as before. As far as the deep water, 14 to 22 feet, extending, the apron was made 40 feet wide, and the body of the dam placed 20 feet still farther up stream, making the base 60 feet wide. With the exception of the first mat, 100 feet long, which turned over and carried away the piles below it, no difficulty was experienced in sinking loose brush in mats several feet thick. I subsequently obtained some brush tied in bundles about 10 inches in diameter, and prefer to handle it in that shape rather than loose.

Great delay having been experienced in the delivery of rock by the parties who had undertaken to furnish it, and from the scarcity of barges suitable to handle it, arrangements were made for the employment of a dredge and tender to deliver gravel, which was discharged from the dump-boats which were dropped down endwise between the piles; after dumping the lower pockets they were withdrawn, turned around, and returned to dump the load from the other end, thus placing all the material on the line of the dam.

Before this work was entirely completed the cold weather caused a cessation of work on the 17th of November, and the full benefit expected to be derived will not be

received from the dam during the winter, but as it was up to the surface nearly all its length it should exercise considerable effect on the current during low stages. For the same reasons the cost of materials in the dam has been greater, per yard, than was expected.

Very respectfully,

O. N. CHAFFEE,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 4.

COMPLETION OF WORK OF REMOVING SAND-BAR IN MISSISSIPPI RIVER OPPOSITE GUTTENBERG, IOWA.

The proposed work at this point is shown in a report dated September 18, 1880.

Under an allotment of $3,000 from appropriation for improving Mississippi River, Saint Paul to Des Moines Rapids, the work of closing Swift Slough with a brush and stone dam was commenced November 4, 1880. The early close of navigation soon interrupted the work, which is fully described in the report of United States Civil Engineer M. Meigs, under head of "Improving Mississippi River, Saint Paul to Des Moines Rapids."

The object of this improvement is, by closing Swift Slough, to effect a crossing over a bad bar in Guttenberg Channel, just above the town.

The appropriation of $5,000, made by act of March 3, 1881, will be expended in completing the work already commenced. As present plans do not contemplate any further work in this channel, and as it is probable that by the work to be done boats will be enabled to reach Guttenberg from the head of the channel, no further appropriation is asked for.

ABSTRACT OF APPROPRIATIONS.

By allotment of act approved June 14, 1880	$3,000 00
By act approved March 3, 1881	5,000 00
	8,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$5,000 00
July 1, 1881, amount available	5,000 00

U 5.

REMOVAL OF BAR IN THE MISSISSIPPI RIVER, OPPOSITE DUBUQUE, IOWA.

The original project for this work is given in my last annual report, and will be found in report of Chief of Engineers for 1880, page 1532.

No work was done under this appropriation during the year, further than a survey in the vicinity of the railroad bridge, and an occasional examination to determine the condition of the bar, in front of the Dubuque Wharf.

Apparently this bar is not reforming, and it is possible that the improvement already made will be permanent, and that the spur-dams

proposed to be built from the Illinois shore will not be immediately required.

During last summer a very troublesome bar formed in front of the warehouses and wharf, at East Dubuque, causing the ferry-boat to run through the draw and land above the bridge.

The expediency of removing this bar was not taken into consideration, as no money was available for the purpose.

A special report was submitted December 31, 1880, on the subject of converting Waples Cut into an ice harbor, at an estimated cost of $40,000. Ice harbors are very important, and much needed on the upper river, and, as Dubuque possesses superior advantages for such a harbor, its construction would seem most judicious.

As the few dredges on the upper river are in great demand elsewhere, it is not proposed at present to do any work in the harbor, unless, during low-water, the bar in front of Dubuque should prove troublesome.

The balance now available will probably be sufficient to carry on work in connection with the removal of the bar, that may be necessary during the fiscal year ending June 30, 1883, and, therefore, nothing is asked for under this appropriation.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$15,000
By act approved June 18, 1878	10,000
By act approved March 3, 1879	4,000
By act approved June 14, 1880	7,000
By act approved March 3, 1881	5,000
	41,000

There passed Dubuque Bridge, during season of 1880, 3,625 steamboats, 878 barges, and 1,392 rafts.

Money statement.

July 1, 1880, amount available	$7,000 63	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$12,000 63
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		23 52
July 1, 1881, amount available		11,977 11
Amount (estimated) required for completion of existing project		9,770 03

COMMERCIAL STATISTICS OF CITY OF DUBUQUE FOR 1880.

Receipts by river	tons..	97,033
Shipments by river	do...	119,354
Volume of business transactions		$19,085,000

U 6.

IMPROVEMENT OF ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

The work contemplated at the beginning of the fiscal year was:

1. To thoroughly examine the cuts through the various chains.
2. To dredge out the loose rock, and remove any projecting points.
3. To establish channel marks and buoys for the aid of navigation.

Owing to continued high-water, and the difficulty of obtaining a

dredge and outfit at a reasonable price, the survey and dredging were not accomplished.

A small stern-wheel steamer was constructed for use, in connection with the establishment of buoys on the various chains and land-marks, as guides to navigation. Experimental buoys were established and carefully watched, being left through the winter to determine the effect of ice. But two of the buoys withstood the ice, and it was fully demonstrated that they must be reset every spring. During the winter forty-two new spar buoys have been prepared, and the drill scow and launch put in readiness for placing them, when the stage of water permits.

A number of surveys have been made during the year, to determine where dredging of broken rock will be required, and on June 21, 1880, during the flood, a careful gauging of the river was made near Saint Louis Chain, at a stage 1′.35 below highest water mark, giving a discharge of 211,240.79 cubic feet per second.

According to this result the computed discharge at high-water would be 229,117.49 cubic feet per second.

The assistant in charge has been, in addition to his other duties, employed upon the history of this improvement.

With the balance of the appropriation of June 14, 1880, and the new appropriation of March 3, 1881, it is proposed to carry out the unaccomplished portion of the work laid out for last year, and in addition to maintain the buoys upon the rapids.

While the money now available will complete the work, as originally projected, it is hoped that steps may soon be taken to inaugurate the work of widening and deepening the present channel. This was fully referred to in my last annual report.

As there will be a sufficient balance available for the maintenance of buoys during the year ending June 30, 1883, no further appropriation is asked for.

ABSTRACT OF APPROPRIATIONS.

By act approved June 23, 1866	$100,000
By act approved March 2, 1867	200,000
By allotment from appropriation of July 25, 1868	156,000
By allotment from appropriation of April 10, 1869	133,650
By act approved July 11, 1870	150,000
By act approved March 3, 1871	150,000
By act approved June 10, 1872	50,000
By act approved March 3, 1873	50,000
By act approved June 23, 1874	50,000
By act approved March 3, 1875	50,000
By act approved August 14 1876	25,000
By act approved June 18, 1878	30,000
By act approved March 3, 1879	6,000
By act approved June 14, 1880	8,000
By act approved March 3, 1881	8,000
Total	1,166,650

Money statement.

July 1, 1881, amount available	$9,434 21	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$17,434 21
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		6,223 65
July 1, 1881, amount available		11,210 56

U 7.

IMPROVEMENT OF HARBOR AT ROCK ISLAND, ILLINOIS.

A report on the harbor of Rock Island was submitted, November 5, 1879, and is printed in House Ex. Doc. No. 32, Forty-sixth Congress, second session.

It was proposed to remove, by dredging, the bar along the levee and a portion of the large bar which extends from the foot of Rock Island.

Contract was entered into with Whitney & Son, and the work of dredging began August 23 and was continued until October 9, 1880.

The material which was supposed to be mainly sand was found to contain much gravel and tenacious clay, and a modification of the contract based on pure sand was submitted and approved. Considerable dredging was done along the steamboat landings, the material consisting principally of broken rock, and several cuts were made through the bar with a view to creating a current which would keep the wharf free from deposits.

SUMMARY OF WORK.

3,959.30 cubic yards material dredged, at 20 cents	$791 86
1,699.72 cubic yards material dredged, at 50 cents	849 86
1,743.10 cubic yards material dredged, at 66 cents	1,150 45
127½ hours service of rock dredge, at $10	1,275 00
	4,067 17

During winter of 1880–'81, ice soundings were made on the bar to ascertain the condition of the cuts. There remains an available balance of $1,360 from appropriation of June 14, 1880, which will be expended under former contract for dredging along the city wharf when a dredge is available for the work. No project has been made for expending the appropriation of $6,000 of March 3, 1881, as other work on the river of greater importance will occupy all the dredges for a long time to come, and as the appropriation will be available for the fiscal year ending June 30, 1883, no further amount is asked for.

COMMERCIAL STATISTICS OF ROCK ISLAND, ILLINOIS, FOR 1880.

Receipts by river	tons	15,500
Shipments by river	do	7,500
Total carried	do	23,000
Lumber, manufactured	feet	60,782,180
Shingles, manufactured	pieces	5,820,000
Laths, manufactured	do	9,757,000
Pickets, manufactured	do	74,000

There passed Rock Island Bridge during season of 1880, 2,664 steamboats, 642 barges, and 782 rafts.

ABSTRACT OF APPROPRIATIONS.

By act approved June 14, 1880	$6,000 00
By act approved March 3, 1881	6,000 00
Total	12,000 00

Money statement.

July 1, 1880, amount available	$6,000 00	
Amount appropriated by act approved March 3, 1881	6,000 00	
		$12,000 00

July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	$4,255 15	
July 1, 1881, outstanding liabilities	385 23	
		$4,640 38
July 1, 1881, amount available		7,359 62
Amount (estimated) required for completion of existing project		14,759 15

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for dredging in the harbor of Rock Island, Ill.*

Number.	Names and residences of bidders.	For dredging and depositing material near Island 310.	Aggregate.
		Per cubic yard.	
1	H. S. Brown, Hamilton, Ill	$0 21	$0 21
2	Whitney & Son, Keokuk, Iowa	0 20	*0 20

*Contract awarded.

U 8.

IMPROVING MISSISSIPPI RIVER AT ANDALUSIA, ILLINOIS.

The original project of this work, as contained in my report of December 17, 1880, contemplates—

1. The construction of a dam (No. 1) from Illinois shore to Island 321.
2. Protection of head of Island 321 for about 900 feet.
3. Construction of dam (No. 2), with necessary shore protections between Islands 320 and 321.
4. Construction of dam (No. 3) between Islands 319 and 318.

The work projected under appropriation of March 3, 1881, is the construction of Dam No. 1 to an elevation of 2 feet above low-water, the protection of head of Island 321 for about 500 feet, and the laying of foundations of Dams 2 and 3; or as much of the above work as can be performed with the funds available. The contract for the performance of the above-named work has been let to Whitney & Son, of Keokuk, Iowa, but operations have not yet commenced.

During 1880 the shipments by river amounted to about 100,000 bushels.

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1881	$6,000

Money statement.

Amount appropriated by act approved March 3, 1881	$6,000 00	
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	39 55	
July 1, 1881, amount available		5,960 45
Amount (estimated) required for completion of existing project		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		12,000 00

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m. May 20, 1881, *for constructing dams and shore protections of brush and stone at Andalusia, Ill.*

Number.	Names of bidders.	Residence.	2,500 cubic yards stone.		2,000 cubic yards brush.		Aggregate.
			Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Whitney & Son.....	Keokuk, Ia...	$1 85	$4,625 00	$1,25	$2,500 00	*$7,125 00

*Contract awarded.

SURVEY OF THE MISSISSIPPI RIVER AT ANDALUSIA, ILLINOIS.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 17, 1880.

GENERAL: I have the honor to present the following report and accompanying map of a survey of the "Mississippi River at Andalusia, Ill.," made in accordance with your instructions dated June 17, 1880.

The report includes a plan and estimate for the improvement of the harbor of Andalusia so as to permit the entrance and landing of the largest boats used on the Upper Mississippi River at the lowest stages of water. The town of Andalusia is situated on the south channel of the river, about 10 miles below Rock Island, Ill.

It has the most available landing on the Illinois side between Rock Island and New Boston, a distance of about 55 miles, and is the natural outlet of a large part of Rock Island and Mercer Counties for the shipment of agricultural products.

The south channel, on which Andalusia is situated, has never been the *main* channel of the river, being much obstructed by rocks and sandbars, so as to make it unnavigable by the larger boats, excepting at high stages of water. The ordinary approach to the landing is made through the narrow passage called the "Ferry Crossing," between Islands 320 and 321; and the northern end of this passage, as well as that portion of the south channel in front of the town, is so blocked up with sand as to shut out all but the smaller boats at low stages of water. To remedy this difficulty and make the approach to the landing easy for all boats, at all stages, I would respectfully submit the following

PROJECT.

1. The construction of a dam (No. 1) of rock and brush from the Illinois shore, below the town, to Island 321.

This dam, with its crest at an elevation of 3 feet above low-water, would turn the current through the "Ferry Crossing" and insure an increased depth at the head of this passage, as well as across the bar in front of and opposite the landing. This dam will be 1,250 feet in length, and the shore of Island 321, at the north end of the dam, should be protected for a distance of 200 feet.

2. To prevent excessive abrasion at the head of Island 321, the shore should be protected for a distance of about 900 feet. The foot of Island 320 may be allowed to cut away so as to give sufficient width in the passage.

3. The construction of a dam (No. 2), with necessary shore protections, from head of Island 320 to foot of Island 319.

This should be done to prevent the widening and deepening of this passage, which, if permitted, might destroy the beneficial effect expected from Dam No. 1.

The length of this dam is 450 feet, and its crest will be at an elevation of 3 feet above low-water.

4. The construction of a dam (No. 3) to close the narrow passage between Islands 319 and 318. This dam will be 200 feet in length, with its crest at an elevation of 3 feet above low-water.

ESTIMATE.

Dam No. 1:		
3,198 cubic yards rock, at $1.50	$4,797	
2,927 cubic yards brush, at $1	2,927	
		$7,724
Shore protection head of Island 321:		
1,350 cubic yards rock, at $1.50	2,025	
900 cubic yards brush, at $1	900	
		2,925
Dam No. 2:		
1,644 cubic yards rock, at $1.50	2,466	
1,248 cubic yards brush, at $1	1,248	
		3,714
Dam No. 3:		
1,050 cubic yards rock, at $1.50	1,575	
850 cubic yards brush, at $1	850	
		2,425
Engineering and contingencies, say		1,212
Total		18,000

COMMERCIAL STATISTICS.

The amount of grain, potatoes, and apples shipped from Andalusia was in 1880 100,000 bushels. Shipments would be much greater if the approach to the landing were improved so as to admit large steamboats during low-water stages.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

U 9.

IMPROVEMENT OF HARBOR AT MUSCATINE, IOWA.

A report on this harbor submitted January 25, 1879, estimated the cost of removing the accumulated deposit at $19,250. An informal agreement with Whitney & Son was entered into under the appropriation of $7,500, made by act of June 14, 1880.

The work was begun October 11, and continued to November 9, 1880, resumed April 25, 1881, and is now going on.

SUMMARY OF WORK.

23,830 cubic yards material dredged, at 20 cents	$4,766 00

When the appropriation of June 14, 1880, is expended, it is proposed to continue the work of dredging along the city wharf with the new appropriation of $2,500 made by act of March 3, 1881.

Until the channel of the river changes, as is very probable, to the right of Island 335, so that the chute between Island 335 and the Illinois shore can be closed, occasional dredging will be required in Muscatine Harbor. An accurate survey of the locality was made in January, 1881.

The work heretofore done has been partly lost, by filling in over the dredged area, and the original estimate will not cover the work required.

It is believed that $5,000 can be profitably expended during the fiscal year ending June 30, 1883.

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1879	$7,500
By act approved June 14, 1880	7,500
By act approved March 3, 1881	2,500
Total	17,500

Money statement.

July, 1880, amount available	$7,500 00	
Amount appropriated by act approved March 3, 1881	2,500 00	
		$10,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		5,643,51
July 1, 1881, amount available		4,356,49
Amount (estimated) required for completion of existing project		1,750 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		5,000 00

COMMERCIAL STATISTICS OF MUSCATINE, IOWA, FOR 1880.

Lumber manufactured	feet..	54,988,704
Laths manufactured	bundles..	17,170,000
Shingles manufactured	pieces..	18,475,190
Flour, meal, &c., manufactured	bushels..	278,000
Receipts by rail	tons..	30,350
Receipts by river	do...	3,912
Shipments by rail	do...	109,198
Shipments by river	do...	6,205

U 10.

IMPROVEMENT OF RUSH CHUTE AND HARBOR AT BURLINGTON, IOWA.

A project for expending a balance of $12,651.71 was submitted September 24, 1880. It contemplated:

1. The raising and strengthening of Rush Chute Dam.
2. The protection of a small island in Rush Chute, and connecting the island with Rush Island (No. 379) by a closing dam.
3. The construction of a closing dam at the foot of Rush Chute between Islands 374 and 376.

Very great difficulty was experienced in obtaining material, boats, and barges for the work, and the prices necessarily paid were much in excess of our estimates.

Work was commenced October 15 and closed by ice November 18, 1880.

Under informal agreement with Keleher, of Davenport, a large amount of stone has been collected during the winter, and delivery is still going on.

The following work was accomplished during the short working season:

Rush Chute Dam was strengthened, and raised to a height of 4 feet at low-water.

This dam is in an exposed position, and to protect it from the effects of ice it must be still further raised.

The head of Rush Island was protected for a length of 650 feet. The head of the small island in Rush Chute was protected for a distance of 300 feet along its eastern side, but time did not permit of building the small closing dam. Early in February a settling was discovered in the Rush Chute Dam, and after this was repaired a second and more extended settling took place.

These settlements were undoubtedly due to the fact that from the location of the dam and bar at head of Rush Chute a strong current proceeds along the face of the dam. The damage was repaired, and to prevent, if possible, future scour, mats were sunk in front of and on the upper side of the dam.

During the season 2,481 cubic yards of brush and 5,377 cubic yards of rock were put in the works.

The increased cost of material and hire of plant necessitated an allowance of $5,000 from the appropriation from Saint Paul to Des Moines Rapids. Of this amount $813.64 was expended during the year, making the total expenditure on this work during the year, including material collected for future use, $13,465.35, of which amount $285.74 is charged as office expenses.

A large amount of material is now on hand and is being transported to the sites of the works, and as soon as low-water permits the obtaining of brush the building of dams will be resumed. Between the 18th of January and 29th of February, 1881, a detailed survey of Rush Chute was made. The results show decided improvement of channel at the head of Rush Chute and in the chute opposite the little island.

As this work will hereafter be carried on under appropriation for "improving Mississippi River, Saint Paul to Des Moines Rapids," no further appropriation is asked for.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$10,000
By act approved June 18, 1878	10,000
By act approved March 3, 1879	5,000
By act approved June 14, 1880	5,000
Total	30,000

Money statement.

July 1, 1880, amount available	$12,651 71
July 1,1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	12,651 71

CURRENT METER OBSERVATIONS AT BURLINGTON, IOWA.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 4, 1881.

GENERAL: I would respectfully submit the accompanying progress reports of Assistant Engineer G. A. Marr upon the work with current meters carried on near Burlington in 1878 and 1879, together with map showing the section of the Mississippi River operated on and the various positions of the meters. Instructions from the Chief of Engineers, dated

August 30, 1878, assigned to Maj. F. U. Farquhar, Corps of Engineers, certain surveys and examinations desired by the Board of Engineers, constituted by Special Order No. 71, Series of 1878, headquarters Corps of Engineers.

While this work was in progress, with the sanction of the Chief of Engineers a series of observations with current meters and a specially constructed chronograph were inaugurated. These observations were very carefully made, and it is believed the results obtained as regards the section of the river operated in are most accurate. The notes are very voluminous, and as the compilation of results has only been carried on during the winter when no field work was going on, but a comparatively small amount of the work is in such a form that it can be submitted; but as what is already completed may be of interest and benefit, I present the record, reserving for a future report any general remarks which the work as a whole may justify.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT ON USE OF CURRENT METERS AND METHOD OF DETERMINING METER COEFFICIENTS, BY MR. G. A. MARR, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., November 10, 1879.

SIR: I have the honor to submit the following report on meter work and current observations:

THE METHOD OF USING THE BUFF AND BERGER METERS.

It was very necessary first of all to look carefully to the adjustment. The wheel should play freely between the supporting arms, and yet should not be so loose as to endanger the fine platinum points that establish the electric current through the meter. If the wheel was quite loose it would invariably bend the platinum points, and a broken circuit would be the result, not always entirely lost, but too broken to be of value.

This adjustment could not be made with the large screws containing the agates, as unless these screws were set up to the shoulder they would follow up the wheel in its revolution and soon bind or perhaps lock the wheel entirely. To remedy this the large screws were set up to the shoulder after removing the fine screws containing the platinum points. If this made the wheel too light or too loose a small strip of very thin paper was inserted on either side (the side necessary to make the proper adjustment) of the set screws that hold the projecting arms to the meter frames. By this means a very fine and quite permanent set could be made for the arms, and it was then only necessary to make a careful adjustment of the small screws with the platinum points. But before adjusting these small screws it was carefully observed that the wheel had a play in the direction of its axis of about one-fifth of a millimeter. This in the agate bearings gave free and easy motion.

This adjustment being made satisfactorily, the adjustment of the small screws containing the platinum points was made as follows: The screw holding the wheel and its frame to the main part of the meter was loosened so that the wheel and frame could be revolved so as to be either side up. The meter was then connected with a battery and a sounding key put in the circuit.

The wheel was placed in a horizontal position so that its weight would bear on the lower agate. The wheel was then turned so that the platinum wire spring from the insulated wire would rest on the silver portion of the axis so as to close the circuit at that point. The small screw containing the platinum point was then turned up carefully until a circuit was established, which was indicated by the sounding key. At this point, if the screws were turned back a trifle the circuit would be broken again, and generally a change of 10° or even less in turning the screw would make and break the circuit.

This small screw was then left just at the point where a good current was established.

The wheel was then inverted and after turning the screw, already adjusted back just 180°, or half a revolution, so as to be certain to have no current through that point, the other small screw was adjusted in the same manner as the previous one. Then the first screw adjusted was turned up the 180° or half turn that it had been turned back, and the adjustment was complete.

After this adjustment the meter would give a good clear record with the wheel in any position, either horizontal, vertical, or any point between.

The great necessity for having a sounding key in the circuit when adjusting these small screws was that otherwise the screws might be turned too far, when the platinum point would be bent to one side and an imperfect contact would be the result, which would lead to a broken and irregular record.

The propeller meter made by T. S. & J. D. Negus, and used some in connection with the above meters, never needed any such adjustment, as the method of connection for making and breaking the circuit is so simple, and, moreover, is entirely inclosed in a small compartment nearly water-tight.

The instrument was never out of order in that respect during its entire use in the work.

There was also another adjustment to look after in the Buff and Berger instruments. The platinum wire spring that had one end attached to the end of the insulated wire, and the other end resting in a groove on the exterior of the axis, was liable to be disturbed, and if accidentally bent would either give too light a pressure to make a perfect record, or would press too heavily and produce extra friction on the wheel, making it more difficult to revolve, and hence giving a different cöefficient.

To keep the adjustment of the spring as near uniform as possible, and as light as would give a perfect record, the following plan was adopted:

A very delicate balance was procured, and by means of a fine thread attached to the wire and the balance the pressure of the spring was carefully weighed. In order to do this it was necessary to have the same connection with a battery and sounding key in circuit as for the other adjustment. The wheel was turned so that the platinum wire rested on the silver of the axis, which gave a closed circuit. The platinum spring was then lifted by means of the balance and thread and the weight noted just at the point where the circuit would be broken. By this means as light a pressure as would give a good result could be established. It was generally found that a pressure of from 1 to 1½ grams was about as light as the spring could be used and be certain of giving a good result. When first tested some of the springs were found to exert a pressure of from 10 to 15 grams.

METHOD OF DETERMINING METER CÖEFFICIENTS.

The place selected for this work was in "Prairie Slough," where at any stage of water less than 5 feet there was no inlet from above to cause a current, and where there was a depth of from 7 to 11 feet at a 2-foot stage. This gave practically a still sheet of water except such fluctuations as might be caused by strong winds. A base of 800 feet was carefully measured with standard cherry rods prepared from the Coast Survey standard 5-foot rods in the office. The points on the base were designated as follows: At the east end "East Base"; 200 feet from this towards the west was called "¼ Base"; at 400 feet on the center "Middle Base"; at 600 feet, "¾ Base"; and at the end of the 800 feet, "West Base."

A telegraph line and battery were established along the base, having ground connection at each end by large sheets of copper placed in the water. Three signal keys or sounders were used, being placed as "East Base," "Middle Base," and "West Base." An observer with a mean time chronometer was stationed as "East Base." Also, observers at each of the stations along the line. A line for testing the meters was selected out in the slough opposite the base, and range stakes set beyond each end of the line, care being taken to set these stakes so as to make the line in the slough or path of the steam launch parallel to the base, one stake being set about 50 feet beyond the end of the line and theodolite readings taken to it from the ends of the base. Then a stake was set beyond the other end of the line with the same readings, only reversed at the two bases. Other range stakes were set beyond these on a prolongation of the line. This line was selected so as to give, as far as possible, a line that would be but little affected by influences from the bottom or sides of the slough, it being at this place quite uniform in depth.

A frame made of 2 inch gas-pipe was attached to the bow of the launch, and the meter to be tested was placed on a rod attached to the extreme forward end of this frame, and at a point which would carry the meter about 2 feet below the surface and about 10 feet ahead of the launch.

Insulated copper wires were attached to the meter before placing it in the water. These were brought up on the bow of the launch and connected with a battery of six Daniel's cells. A register was placed in the circuit and also a sounding key, which

was placed in the engine room to guide the engineer in keeping the speed of the launch u niform.

Observers were then stationed at the different points 200 feet apart on the base, those at "East Base," "Middle Base," and "West Base" having theodolites.

At the ¼ and ¾ base men were stationed with signal flags. These two bases were provided with boards with slots cut in them and a string or wire stretched longitudinally along the center of the slot. The board and its wire were carefully set in front of and directly opposite each base, and stakes set on the opposite side of the slough, these stakes being set by laying off 90° from the base with a theodolite. The observers at these bases could then give a signal as the launch passed the ranges.

All being ready for work, the launch was got on line outside the limits of the base and prepared to run with as steady and uniform a speed as possible. As the launch approached the point opposite "East Base" the observer there stationed called "ready," held up one hand, and with the other made two breaks on the key or sounder. At this signal the observer on the launch commenced counting and watching the register and the observer at the chronometer took up the "beat." As the prick-staff of the launch passed the cross wire in his telescope the observer dropped his hand quickly, gave one tap on the key, and also called "tick" sharply, so that if the observer on the launch did not happen to be looking and see the hand drop he would get the signal "tick." The signals were all given as distinctly and sharply as possible. The reading on the register was noted, and the time taken to the nearest tenth of a second so far as practicable.

At the next station, or "¼ base," the observer called ready and held up his flag, being in a position where he could be seen both by the observer on the launch and the observer at the chronometer. As the jack-staff passed his station or line of sight he dropped his flag as quickly and distinctly as possible, and called "tick."

The same signals were given at the three remaining stations. At the signal from the ¼ base the reading of the register was noted and the difference of readings at "east base" and "¼ base" gave the number of revolutions or half revolutions, according to the meter used. A return trip was made over the same course, running from "west base" to "east base," using the same speed of boat as far as practicable. The results of these two trips should be combined so as to eliminate effect of current, if any, so far as the current might be expected to remain uniform. The work would be continued with a meter until various speeds of the launch had been tested, or in other words, the meter tested for many different velocities from quite slow to as fast as the register could be read.

For using the meters for current observations, a derrick was put up on the United States quarter-boat Major E. F. Hoffmann. The main spar of the derrick was 35 feet long, and was placed just forward of the cabin, and as near the center as a free use of the door of the cabin would allow. To this spar was attached a boom 25 feet long, being set for this work about 12 feet from the lower end of the spar. A heavy set of double blocks and fall led from the upper end of the spar to the beam, by which the latter could be raised or lowered at will. From the upper end of the boom another double block and fall was used to handle the apparatus for current work. A cable wire rope ⅝ inch in diameter and 32 feet long was prepared with an eye at the upper end for the hook of the block, and a mushroom anchor weighing 750 pounds was attached to the lower end of the cable by means of a clamp clevis, as the lower end of the wire cable had to be free so as to pass through the current meter frame. To the anchor was attached a bar of iron 1 by 3 inches and about 3 feet long. On the outer end of the bar rested a gas-pipe 1 inch in diameter, made in lengths of 10 feet, and provided with couplings, one side of the gas-pipe being perforated with ½-inch holes for the introduction of the insulated wires that were to connect the meters with the battery and the chronograph. This pipe was used to prevent the wires from becoming entangled in the meters, and the pipe and system of wires were always placed so as to be down stream from the meters.

Six meters were used on these current observations, and were usually set on the wire cable equidistant from each other, and the same distance from the bottom and surface of the river; for instance, in 21 feet depth of water the upper meter would be 3 feet below the surface, and 3 feet between the meters, the lower one being 3 feet above the bottom.

In order to give frequent direct comparison between the 6 meters, a frame was prepared of oak pieces 2½ by 6 inches, the frame being 12 feet long and 2½ feet wide. Six iron bolts of ¾ inch round iron, and about 2¾ feet long, were set in the frame to support the meters, the bolts being placed 2 feet apart and 1 foot from either end. A piece of ¾-inch gas-pipe was set in the center of this frame and provided with a clamp screw.

In use the wire cable was passed through the gas-pipe in the center of this frame, and placed and clamped at a point where the center of the frame would be about 2 feet below the surface of the water when the anchor was on the bottom. This placed the frame in a horizontal position, and stay-rods were used attached from the ends of

the frame to the bow of the quarter-boat, so as to hold the frame at a right angle to the direction of the current.

The meters were placed on the frame and carefully set at the same height. This gave comparison of the meters at the same depth, and in order to eliminate any effect from lateral difference in the current, the meters were used in reverse positions on the frame.

There was also a comparison made between the meter and the ordinary float used for gauging, both tin floats and paint kegs.

This work was done as follows:

A section of the river, giving as uniform a channel as possible, was selected on the east side of bar *h* in the main channel. Five meters were used in this comparison, being placed equidistant, as in other work, which placed one of the meters at mid-depth. This left one pen on the chronograph for recording float observations. A base of 200 feet, marked at each 50 feet, was carefully measured with the standard cherry rods, in a direction as nearly parallel to the direction of the current as practicable.

Telegraphic communication was established between the base stations and the chronograph on board the quarter-boat, break-circuit keys being used at the two ends and the middle of the base. The quarter-boat was anchored so that the cable with the meters would be placed about 16 feet below the lower base. The skiff containing the floats to be sent was then anchored about 100 feet above the upper base, and trials made with floats until the point was found from which the floats would pass from the skiff directly toward the cable containing the meters. Work was then commenced, a continuous record of the five meters being made on the chronograph. A warning of several breaks was given just before the single break of the passage of the float.

Theodolites were used at the two ends and the middle of the base, and signal flags at the points 50 feet from either end, one of the observers at a key watching the flag and marking the signals.

The observer at the lower base took a theodolite reading to the float as it passed the upper base, and the observer at the upper base did the same as the float passed the lower base, thus giving the path of the float. The larger number of the observations were made with the floats tied at mid-depth, the remainder being taken with the floats tied at depths corresponding to the positions of the meters next above and below that at mid-depth. Time was also taken with a mean-time chronometer, in order to give comparison between this method and the chronograph.

Very respectfully, your obedient servant,

G. A. MARR,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

PROGRESS REPORT ON REDUCTION OF CURRENT-METER OBSERVATIONS, BY MR. G. A. MARR, ASSISTANT ENGINEER.

OFFICE UNITED STATES ENGINEERS,
Rock Island, Ill., June 30, 1881.

CAPTAIN: I have the honor to submit the following progress report on the reduction of current-meter observations, taken during season of 1879, in the Mississippi River, near Burlington, Iowa:

For this special work, ordered by the Board of Engineers, and executed mostly under the direction of Col. F. U. Farquhar, Major of Engineers, preparations were made to obtain a more thorough system of observations than had heretofore been realized. On account of the great fluctuations in velocity, and sudden changes or pulsations, not only from the surface downward, but also in the whole volume of water, a system that would give simultaneous observations at several distinct points in a vertical plane would give much more reliable and valuable information. For this purpose, six of the best make of Buff & Burger telegraphic current-meters were used at the same time. In order to have a perfect record for the results of these meters, a chronograph with eight pens was designed by Colonel Farquhar, and made under his direction, by T. S. & J. D. Negus, of New York.

This instrument was very complete, and answered admirably for this work. With eight pens working independently, six could be used for the six current meters, giving for each meter an independent and complete record of the parts of revolutions; and the two outside pens used for time, being connected with a break-current sidereal chronometer, and marking intervals of 1 second on each edge of the sheet.

From this record data could be obtained in any manner desirable, either the number of revolutions and parts of revolutions in a given time, or the time of a single revolution or a part of a revolution taken to the fraction of a second. The speed of the chronograph was such as to make the second intervals about one-fourth of an inch.

The method of determining meter cöefficients has been fully given in my report of November 10, 1879, at the close of field work. In the reduction of the work the following plan was adopted:

In order to eliminate the effect of current, if any existed, the observations were combined in pairs, a down trip and the following up trip constituting a pair. The time of transit and the number of revolutions being noted at each 200 feet of the 800 feet base, it became divided into four equal sections, numbered from east base consecutively 1, 2, 3, and 4. In combining these separate sections, that having the greatest time interval on the down trip was combined with that having the greatest time interval on the up trip. In this way 4 equations of condition would be formed from each round trip from east base.

The formula used for these determinations, $v = an + b$, is that of a straight line referred to rectangular co-ordinates. In the above equation as used in this work, $v =$ velocity in feet, and $n =$ number of revolutions of meter per second, quantities that become known from the observations, and hence a and b are the quantities to be derived from the equations. The quantity a becomes the tangent of the angle which the line makes with the axis of abscissas, and b the distance from the origin to where the line intersects the axis of ordinates.

In the determination of cöefficients the observations have been such as to give from nineteen to thirty-nine equations of condition from which to derive final results for the two quantities a and b. These equations have been solved by method of least squares, and the results are given in Table I. Also the quantities v and n in each equation of condition have been plotted with a system of rectangular co-ordinates, and are shown on Plates I, II, III, and IV. These are given to show how closely the observations agree with a straight line making an angle with the axis of abscissas, the tangent of which is equal to a, and the point of intersection of the line with the axis of ordinates is a distance from the origin equal to b.

Great care was exercised in handling the meters that nothing should occur liable to affect these values of cöefficients. But in order to detect any change the horizontal frame described in the report of 1879 was used generally between each set of observations in a vertical plane. A number of these observations, sufficient to show any material change in the cöefficients, has been worked up. One set of observations reduced is given with this present report to give an idea of such observations. This work done on October 7, 1879, is given in Table 2.

A comparison on a horizontal frame cannot be expected to give definite results such as would be of value in determining cöefficients of one meter from another on account of variations in velocity even in so small a section as 12 or 15 feet.

The observations of October 7 were taken in the channel between the Iowa shore and the first sand-bar above Burlington (bar h). This is a straight and well-defined channel at the point where the observations were taken, but becomes more shoal a few hundred feet above. It evidently was the main channel not many years ago. In the computations the average velocity for one minute of time was determined as giving the best results for showing the vertical velocity curves. On this date the meters were used in two positions, giving a change in the depth of water. The results for each minute are given in Tables 3 and 4. The results are also plotted on section-paper, giving the vertical velocity curves geographically. Those for this date are given for each minute on Plates V and VII.

The mean results for each position of meters are also plotted on a larger scale, and approximate curves drawn.

In drawing the mean curve no attempt was made to have the curve that of a parabola; the only rule adopted was to have the curve as nearly symmetrical as possible above and below the apparent axis, the lower part of the curve being drawn first. From this curve values are taken for each 0.2 foot in depth, giving 97 results in one case and 106 results in the other. Final mean velocities are derived from these separate results, also the mid-depth velocity taken off graphically. This gives a valuable comparison between the mean and mid-depth velocities. The formula of Humphreys and Abbot, given on page 314 of their report, was also used to derive a mean velocity from the mid-depth velocity as taken from the curve.

The value of v in the formula, or the mean velocity of the whole river, was taken from the mean velocities as determined on cross-section No. 1 of gaugings, the velocities for the different stages being plotted on section paper, and a line drawn approximately through the different points, from which the value of v could be taken very closely for any stage, and especially as the gaugings had been taken at about the same time as these current observations. These final curves for October 7, with their reduced and derived results, are given on Plates VI and VIII.

The same comparisons have been made for the work of October 11 and October 14.

The position of the boat on October 11 was a few feet below cross-section No. 1, and was in about 11 feet depth of water on a flat middle ground, where the current might have a slight tendency to divide. The water also became more shoal a few hundred feet down stream.

The results here indicated a much greater surface velocity than the work of October 7. This might arise from the shoaling of the water below. There was perceptible wind. Twenty floats were sent down over cross-section No. 1 during the observations of October 11, but the results have not yet been reduced. As the comparisons between meters and floats on October 28 were so much more complete, they have been reduced first.

The results for the two different positions on October 11 are given in Tables 5 and 6. Also, plotted curves for the single results of these two tables are given on Plates IX, X, and XI, and curves for final reductions on Plate XII. In the work given on Plate XII for 67 minutes, a value for mean velocity was also derived by connecting the plotted points by straight lines, and taking off values from this broken line as well as from the curve, the result being a close agreement, showing that with quite irregular results a mean curve can easily be drawn giving a good mean.

The work of October 14 was taken directly in the main channel of the river in about 13 feet depth of water, and where the channel was quite uniform and direct for nearly a mile—that is, the steamboat channel, from 300 to 500 feet wide, but not a section of the whole river. The results for three different parts of this work have been reduced and are given in Tables 7, 8, and 9, and the plotted curves for single results on Plates XIII and XIV, and the final curves on Plates XV and XVI.

The results from all these final curves are given in Table 10.

As some of the most valuable observations have not yet been reduced, no attempt has been made to derive a general formula for obtaining mean from mid-depth velocity. When the work has all been reduced, a great number of equations of condition can be formed to determine the best cöefficients or constants necessary to derive a mean velocity from an observed mid-depth velocity, or perhaps determine a proportioned depth for mean velocity with sufficient reliability that floats can be tied at a proper depth to give as close approximation to the mean velocity as can be derived from a mid-depth velocity.

The comparisons between current meters and floats on October 28 have been reduced and results plotted on section paper. The place selected for this comparison was in the main steamboat channel just east of Bar "h," where the main part of the channel was so straight and uniform that it would be expected to give a valuable comparison.

A full description of the method of making these comparisons has been given in my former report. The work was reduced by determining the velocity of the float over each section of 50 feet, and also for the meter at mid-depth for the next consecutive time after the passage of the float, and for a time interval equal to that of the float over the last section of 50 feet. From an inspection of the results it was found that the velocity was not uniform over the different sections of 50 feet, and hence a direct comparison of the velocity of the float with a meter just below the section could not be expected to give definite results. Therefore the different values were plotted on section paper, and curves drawn showing that the velocity over the different sections continued relatively about the same; that is, the velocity over the second section was invariably less than that over the first section, although the velocity changed materially during the whole series of 10 floats. The paths of the floats were plotted, and when they diverged from a parallel sufficiently to make a perceptible increase in the distance, the distance as taken from the plot was used. Only one of the eight series is given in this progress report. The velocities given by the five meters during the passage of the floats were all reduced for the time of each section, thus giving the five velocities in a vertical plane, as shown by the meters in their position below the base, while the floats were passing over each section of the base. These vertical velocity curves have also been plotted opposite each curve for the five sections.

The results are given in Table 11, and curves on Plates XVII, XVIII, and XIX.

There is also a graphical delineation of the changes in velocity during the time of this series of 10 floats, which is given on Plate XX. The number of quarter revolutions in 10 seconds for each of the 5 meters is plotted with a vertical scale of number of quarter revolutions in 10 seconds, and a horizontal scale of time.

It will be observed that there are quite extreme changes in velocity, especially near the bottom, amounting in some instances to nearly half the greatest velocity in less than 1 minute of time.

These changes or pulsations, as will be seen, are much greater at the bottom than near the surface, and also that the changes generally occur at about the same time from the surface to the bottom, and not, as has been heretofore inferred, that when the velocity at the surface was momentarily increased there would be a corresponding slow velocity at the bottom, and *vice versa*.

The time for each float in passing opposite the 200-foot base is also shown by braces. It will be seen that generally it includes a sufficient number of pulsations to give a good average velocity.

It may be well to state here that the quarter-boat was always securely anchored in four directions. Two heavy anchors, with lines leading off, quartering from the bow or up stream, from 150 to 200 feet distant, and also 2 anchors at the stern in the same

manner. This would allow but very little motion to the quarter-boat. Then, as the lower end of the cable was fastened to a 750-pound mushroom anchor, there was no possibility of any perceptible swaying of the meters near the bottom. If any variations in velocity were caused by a swaying of the meter cable the changes would be much greater near the surface than near the bottom. The reverse of this is true, or the greater pulsations occur nearer the bottom. Also, these pulsations cannot be referred to the effect of wind, or the pulsations should be greater near the surface.

A full development of these curves, with actual velocities for each 10 seconds, or even less, instead of revolutions, will give valuable data for study in regard to effect of wind or rising or falling stages of water. Unfortunately, the stage of water during most of the work was quite uniform, and hence the effect of extreme changes cannot be investigated. These curves could also be used for a study of the connection between these pulsations in the velocity of the current and land waves.

A table of velocities corresponding to any number of revolutions can be prepared for each meter, and such velocity curves plotted readily from these tables by merely counting the number of revolutions and referring to the tables.

A statement is given in Table 12 of the amount of meter work that was accomplished, and the proportion that is reduced. On account of the reductions of meter cöefficients, a greater proportion of the reduction has been accomplished than would appear from the table.

Very respectfully, your obedient servant,

G. A. MARR,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 11.

IMPROVEMENT OF HARBOR AT FORT MADISON, IOWA.

No work was done during the fiscal year, there being no funds available. The project for the expenditure of $2,500 appropriated by act of March 3, 1881, has not yet been presented, it being deemed advisable to await the subsidence of high-water before making the examination necessary in its preparation.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$10,000
By act approved June 18, 1878	8,000
By act approved March 3, 1879	3,600
By act approved March 3, 1881	2,500
	14,100

Money statement.

Amount appropriated by act approved March 3, 1881	$2,500	00
July 1, 1881, amount available	2,500	00
Amount (estimated) required for completion of existing project	6,086	87
Amount that can be profitably expended in fiscal year ending June 30, 1883.	6,086	87

U 12.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT AND ABOVE THE CITY OF ALEXANDRIA, MISSOURI.

The original project for this work is given in Report of Chief of Engineers for 1879, page 1150.

Contract was made with W. A. & J. C. Patterson, of Keokuk, Iowa, under date of August 6, 1880. Work was commenced August 26 and

closed October 19. Details of the work are given in accompanying report of Assistant Engineer O. N. Chaffee.

With the appropriation of $6,000 made by act of March 3, 1881, it is proposed to complete dam No. 2, and a contract for that purpose has been made with the former contractors.

ABSTRACT OF APPROPRIATIONS.

By act approved June 14, 1880	$10,000
By act approved March 3, 1881	6,000
	16,000

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	6,000 00	
		$16,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		10,035 85
July 1, 1881, amount available		5,964 15
Amount (estimated) required for completion of existing project		14,945 75
Amount that can be profitably expended in fiscal year ending June 30, 1883		14 945 75

Abstract of proposals received and opened August 6, 1880, by Capt. A. Mackenzie, Corps of Engineers, for constructing dams and shore protections, of brush and stone, at Alexandria, Missouri.

Number.	Names of bidders.	Residence.	4,000 cubic yards stone.		4,000 cubic yards brush.		Aggregate.
			Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	H. S. Brown	Hamilton, Ill	$1 56	$6,240 00	$1 00	$4,000 00	$10,240 00
2	W. A. & J. C. Patterson	Keokuk, Iowa	1 34	5,360 00	89	3,560 00	*8,920 00
3	James McNamara	do	1 70	6,800 00	80	3,200 00	10,000 00
4	A. J. & C. J. Whitney	do	1 55	6,200 00	95	3,800 00	10,000 00

* Contract awarded.

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m., May 20, 1881, for completing dam and shore protection of brush and stone, at Alexandria, Mo.

Number.	Names of bidders.	Residence.	2,000 cubic yards brush.		2,500 cubic yards stone.		Aggregate.
			Price per cubic yard.	Amount.	Price per cubic yard.	Amount.	
1	W. A. & J. C. Patterson	Keokuk, Iowa	$1 23	$2,460 00	$1 73	$4,325 00	*$6,785 00
2	H. S. Brown	Hamilton, Ill	1 30	2,600 00	1 85	4,625 00	7,225 00
3	A. J. Whitney	Keokuk, Iowa	1 25	2,500 00	1 75	4,375 00	6,875 00

* Contract awarded.

REPORT OF MR. O. N. CHAFFEE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., March 12, 1881.

SIR: I have the honor to present a report of work done for improvement of Mississippi River near Alexandria, Mo., during season of 1880.

The contract was assigned to W. A. & J. C. Patterson, of Keokuk, Iowa, on August 6, 1880. Work was begun on the 26th of August, and closed October 19.

Mr. J. D. Du Shane performed the duties of inspector in a satisfactory manner.

The work proposed was two dams from Missouri shore, the first about 1,550 feet above warehouse at Alexandria, and the second about 2,000 feet further up stream, on the same side, the object being to deepen the crossing opposite the head of the second dam. Dam No. 1 was built from shore across the deep water to a dry sand-bar at a distance of 910 feet, and to an elevation of 4 feet above low-water. Of dam No. 2, one layer of brush was laid in the foundation, and a portion of the second layer, leaving 680 feet more to be put in.

Work was suspended at this point on account of expenditure of appropriation.

STATEMENTS OF MATERIAL AND COST.

3,866.06 cubic yards stone, at $1.34	$5,180 52
4,551.05 cubic yards brush, 89 cents	4,050 43
Total	9,230 95

Very respectfully, your obedient servant,

O. N. CHAFFEE,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 13.

IMPROVEMENT OF NAVIGATION OF THE MISSISSIPPI RIVER AT QUINCY, ILLINOIS.

Under this head $25,000 was appropriated by act of June 14, 1880. The project for its expenditure contemplated the use of $15,000 for the improvement of the river, and $10,000 for Quincy Bay.

A contract dated August 6, 1880, was made with H. S. Brown & Co., for the work in the bay. Work was commenced August 23, with two dredges, and continued until the end of the month, when the fleet was sent to Hannibal.

Work was resumed May 4, 1881, and is now going on.

An informal agreement has been made with H. S. Brown & Co. to close Squaw Chute whith a brush and stone dam, and this work is about completed, its object being to prevent the washing of sand from the main river into the lower portion of the bay.

STATEMENT OF WORK.

6,760.25 cubic yards material dredged, at 18 cents	$1,216 84
8,545.00 cubic yards material dredged, at 20 cents	1,709 00
Total	2,925 84

It is proposed to expend a portion of the balance on hand for dredging, and piling along the lower end of the bay, on the west side, at the site of the government depot, and the remainder in improving the river in the vicinity of Quincy, in continuation of work done in 1879.

As the work of improving the bay—which is most important as an

ice harbor—will hereafter be carried on under the appropriation for "Improving Quincy Bay", no further appropriation is asked for, under the head of "Improving navigation of Mississippi River, at Quincy, Ill."

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1879	$20,000
By act approved June 14, 1880	25,000
Total	45,000

Money statement.

July 1,1880, amount available		$25,252 72
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	$4,375 44	
July 1, 1881, outstanding liabilities	292 58	
		4,668 02
July 1, 1881, amount available		20,584 70

Abstract of proposals received and opened August 6, 1880, by Capt. A. Mackenzie, Corps of Engineers, for dredging in Quincy Harbor, Illinois..

No.	Names and residences of bidders.	For dredging in Quincy Harbor, Illinois *	For dredging in Quincy Harbor, Illinois.†	Aggregate.
		Per cubic yard.	*Per cubic yard.*	
1	Whiting & Son, Keokuk, Iowa	$0 20	$0 22	$0 42
2	H. S. Brown, Hamilton, Ill	18	20	‡ 38

* Material to be deposited at a distance not exceeding 1 mile.
† Material to be deposited at a distance not exceeding 2 miles.
‡ Contract awarded.

U 14.

IMPROVEMENT OF QUINCY BAY, ILLINOIS.

The project for this work is given in Report of Chief of Engineers for 1879, page 1130.

A contract for dredging in Quincy Bay, under this appropriation, was awarded to H. S. Brown & Co. As the work of their former contract, under appropriation for "Improving navigation of Mississippi River at Quincy," is not completed, this work cannot be commenced immediately.

As with all dredging work on the river, the improvement of Quincy Bay has been delayed by the scarcity of dredges, but as it is hoped the United States will soon be enabled to assist in such work with dredges of its own, this delay may in the future be avoided. With this in view, and as a means of inducing more competition, and an ultimate reduction in cost of work, and in obtaining as soon as possible the benefits desired, I consider that an appropriation of $50,000 would be greatly for the interest of the work. It is proposed with the money now available to continue dredging in the bay, below the bridge on the west side of the bay, and to open a new channel from the deep water below the bridge to the various lumber yards, &c., on the east side.

ABSTRACT OF APPROPRIATION.

By act of March 3, 1881 ..... $10,000 00

Money statement.

Amount appropriated by act approved March 3, 1881	$10,000 00
July 1, 1881, amount available	10,000 00
Amount (estimated) required for completion of existing project	169,109 87
Amount that can be profitably expended in fiscal year ending June 30, 1883.	50,000 00

COMMERCIAL STATISTICS OF QUINCY, ILLINOIS, FOR 1880.

Volume of business transactions		$120,579,168
Ice cut for shipment by river	tons	161,000
Internal-revenue collections		$1,137,771
Freight received by rail	tons	592,520
Freight shipped by rail	do	560,600
Freight received and shipped by river	do	60,000

There passed through Quincy Bridge during 1880, 1,831 steamboats, 616 barges, and 349 rafts.

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m., May 20, 1881, for dredging in Quincy Bay, Illinois.

Number.	Names of bidders.	Residence.	Price per cubic yard for dredging.		
			Depositing at a distance not exceeding 1 mile.	Depositing at a distance not exceeding 2 miles.	Aggregate.
1	Whitney & Son	Keokuk, Iowa	$0 22	$0 25	$0 47
2	H. S. Brown	Hamilton, Ill	20	23	*43

* Contract awarded.

U 15.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT HANNIBAL, MISSOURI.

The original project for this work is given in Report of Chief of Engineers for 1880, page 1546.

The work, which was commenced on September 1, 1880, under contract with H. S. Brown & Co., and closed November 17, is fully described in the accompanying report of Assistant Engineer O. N. Chaffee. In April, 1881, the available balance, amounting to $1,200, was expended in dredging out a portion of the gravel bar in front of the lower end of the city wharf.

With the appropriation of $20,000, now available, it is proposed to continue work under original project, and a contract has been entered into with H. S. Brown & Co. to perform it.

SUMMARY OF WORK.

In 1880, for closing dam:

13,481.5 cubic yards gravel, at 60 cents	$8,088 90
16,018.5 cubic yards sand, at 20 cents	3,203 70
4,105.57 cubic yards rock, at $1.45	5,953 08
366.0 cubic yards brush, at 90 cents	339 49

In 1880, for wing-dam:	
6,394.04 cubic yards gravel, at 60 cents	3,838 31
7,597.29 cubic yards sand, at 20 cents	1,518 96
Total	22,942 44
In 1881, dredging at lower levee:	
6,019.25 cubic yards material dredged, at 20 cents	1,203 85
Total during fiscal year	24,146 29

ABSTRACT OF APPROPRIATIONS.

By act approved June 14, 1880	$25,000
By act approved March 3, 1881	20,000
Total	45,000

Money statement.

July 1, 1880, amount available	$25,000 00	
Amount appropriated by act approved March 3, 1881	20,000 00	
		$45,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		24,906 61
July 1, 1881, amount available		20,093 39
Amount (estimated) required for completion of existing project		15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		15,000 00

COMMERCIAL STATISTICS OF HANNIBAL, MO., FOR 1880.

Volume of business transactions:

Agricultural implements	$90,000
Blank books and stationery	160,000
Boots and shoes	200,000
Breweries	85,000
Clothing	750,000
Dry goods	800,000
Drugs, oil, &c	250,000
Groceries	1,350,000
Hardware and iron	130,000
Leather and findings	100,000
Oil and salt	850,000
Tobacco and cigars	145,000
Lumber	2,225,000
Founderies, machine and boiler shops	800,000
Flouring-mills	800,000
Lime	75,000
Planing-mills	800,000
Saw-mills	400,000
Cooperage	160,000
Pork and beef packers	280,000
Ice	92,000
Wagon and carriage factories	125,000
	10,467,000

There passed through Hannibal Bridge in 1880, 1,925 steamboats, 760 barges, and 1,479 strings of lumber.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for construction of dams and shore protections, of brush, stone, and gravel, near Hannibal, Mo.*

Number.	Names and residences of bidders.	6,500 cubic yards stone.		4,000 cubic yards brush.		4,500 cubic yards gravel.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Whitney & Son, Keokuk, Iowa	$1 55	$10,075 00	$0 95	$3,800 00	$0 25	$1,875 00	$15,750 00
2	H. S. Brown, Hamilton, Ill,	1 45	9,425 00	0 90	3,600 00	0 25	1,875 00	*14,900 00
3	Fruin & Co., Saint Louis, Mo.	1 65	10,725 00	1 00	4,000 00	0 35	2,625 00	17,350 00

* Contract awarded.

Abstract of proposals received and opened August 11, 1880, *by Capt. A. Mackenzie, Corps of Engineers, for dredging at Hannibal, Mo.*

Number.	Names and residences of bidders.	22,000 cubic yards gravel, and depositing the material.		Sand and mud, and depositing the material.		7,500 cubic yards gravel, and depositing on decked flats.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	H. S. Brown, Hamilton, Ill.	$0 60	$13,200 00	$0 20	.....	$0 65	$4,875 00	*$1 45
2	A. J. Whitney, Keokuk, Iowa	66	14,520 00	22	.....	66	4,950 00	1 54

* Contract awarded.

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m. May 20, 1881, *for constructing dams and shore protections of brush, stone, and gravel, and dredging at Hannibal, Mo.*

Number.	Names of bidders.	Residence.	4,000 cubic yards stone.		2,500 cubic yards brush.	
			Per cubic yard.	Amount.	Per cubic yard.	Amount.
1	Whitney & Son	Keokuk, Iowa	$1 75	$7,000 00	$1 25	$3,125 00
2	H. S. Brown	Hamilton, Ill	1 56	6,240 00	1 00	2,500 00

Number.	Names of bidders.	For dredging and depositing material in chute east of Glasscox Island.				For dredging and depositing material on decked flats and shoveling into dam 7,500 cubic yards gravel.		Aggregate.
		11,000 cubic yards gravel.		11,000 cubic yards sand and mud.				
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Whitney & Son	$0 45	$4,950 00	$0 25	$2,750 00	$0 70	$5,250 00	$23,075 00
2	H. S. Brown	50	5,500 00	20	2,200 00	60	4,500 00	*20,940 00

* Contract awarded.

REPORT OF MR. O. N. CHAFFEE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., February 10, 1881.

CAPTAIN: I have the honor to present the following report of work done for improvement at Hannibal, Mo., during the season of 1880. The contract was awarded

to H. S. Brown & Co. on August 10, and work was begun September 1 and closed November 17.

The work comprised the partial removal of a gravel bar, which extended from the shore above the city diagonally down stream to a point opposite the K. N. L. Packet Company's warehouse, and distant from it about 400 feet, which was dry at low-water in many spots, and the removal of a gravelly and stony point from the shore about 450 feet above the warehouse, which together created a constant eddy along the levee and caused a deposit of mud sufficient in time to entirely prevent the landing of boats.

Included in the plan, in addition to the removal of these bars, was the construction of a closing dam from Glasscox Island to the Illinois shore, and such wing-dams as might be found necessary to deflect the current to the Missouri shore and prevent the deposit of mud in future along the levee. The width of the passage between the Illinois shore and Glasscox Island is 1,440 feet and the average depth about 5 feet below low-water. The banks of alluvial deposit, about 7 feet high, were sloped and protected with brush and stone in the customary way for 50 feet above and 150 feet below the dam; mats were extended out 60 feet into the river, from the shore protection on the line of the dam, and sunk with rock. The main body of the dam was made by dumping the materials dredged at Hannibal on the line of the dam. These materials were composed of fragments of granite from the size of 2½ inches in diameter to fine sand. For determining the "grade" of material, whether "gravel" or "sand," into which it had been decided to divide it, paying for gravel the contract price, and for sand 20 cents per yard instead of the contract price, a cubic foot of it, as delivered from the dredges, was weighed every day, the sand sifted out with a screen having a mesh ¼ inch square. Whatever passed through was termed sand, and the remainder gravel. The percentage of gravel on the whole work was 45.7.

The deposit of materials in the dam was begun about the middle of the chute and continued towards both banks by 2 tow-boats, which put in an average of 790.75 cubic yards per day. At first the placing of the dump-boats on the line of the dam was performed easily, but after the channel had been considerably narrowed the current was greatly increased and it became more and more difficult to hold them on line. Though piling had been driven to assist the steamboats it often failed to resist the strain, and much material was deposited off the line, and a considerable quantity was washed away by the current. It is safe to say that this dam is upwards of 150 feet wide on the bottom, while the average height of gravel is but 6½ feet. About October 19 it was discovered that the dam had given way in the middle and a gap had been formed about 150 feet wide and 22 feet deep, through which the water rushed apparently with irresistible force. There being no probability of restoring the work by dumping the material from the dredges into the gap, rock was brought in considerable quantity, and after about 2,000 cubic yards had been put into the gap the dam was again brought to the surface and finally built up to an elevation of 2 feet above low-water across the whole distance. Before it could be built more than 4 or 5 feet wide at top cold weather caused a suspension of operations. A wing-dam, located about 3,100 feet above the closing dam, was begun from the Illinois shore, and material dumped in along its line for a distance of about 600 feet, sufficient to make a good foundation. The condition of the gap in the closing dam rendering it uncertain whether the appropriation would be sufficient to close it, dredging was discontinued on November 3, and nothing more was done on the wing-dam. The compactness of the dredged material renders the dam impervious to water, and when the water stood at such a grade that but little flowed over the dam, the difference of level above and below the dam was 17½ inches. This quantity divided by the slope of the river at this locality indicates that the effect of the dam extended about 5,000 feet above and below it. A strong current was developed around the head of Glasscox Island, where some shore protection will be necessary as soon as further appropriations become available. It is suggested that the closing dam should be raised and strengthened both with rock and gravel sufficiently to insure its permanence under all circumstances likely to occur. By the terms of the contract dredged materials were required to be dumped in the passage behind Glasscox Island, so that the expense of constructing a dam out of them was nothing. By this arrangement the cost of the dam was much reduced.

It was expected that this experiment would furnish a favorable solution to the question whether dams can be built of gravel alone. Our experience thus far does not seem to warrant the construction of long closing dams of gravel exclusively. Used in conjunction with brush and stone, finishing the top entirely with the latter material, the stability of the dam will not be impaired, while the cost will be considerably diminished from what it would be in the usual way of building.

Mr. W. A. Thompson during a part of the season, and Mr. J. C. Wall during the whole time work was in progress performed the duties of inspectors in a zealous and satisfactory manner.

Very respectfully, your obedient servant,

O. N. CHAFFEE,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

U 16.

IMPROVEMENT OF MISSISSIPPI RIVER AT LOUISIANA, MISSOURI.

The original project for this work was submitted December 22, 1880, and is printed in House Ex. Doc. No. 37, Forty-sixth Congress, third session.

It contemplates:

1. Construction of spur-dam (No. 1) from Illinois shore opposite elevator at Louisiana.
2. Removal of pile of rocks in the channel below the bridge.
3. Closing of Buffalo Island Chute (No. 2).
4. Construction of spur-dam (No. 3) from Illinois shore about 1 mile below the bridge.
5. Protection of eastern shore of Buffalo Island.
6. Construction of closing dam (No. 4) in Brokau Chute.

The work projected under appropriation of March 3, 1881, is the construction of dam No. 1.

The contract has been let to W. A. & J. C. Patterson, of Keokuk, Iowa.

Work was commenced in June, but as no disbursements on this account have yet been made, it will be included in my next annual report.

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1881	$10,000

Money statement.

Amount appropriated by act approved March 3, 1881	$10,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	48 38
July 1, 1881, amount available	9,951 62
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	45,000 00

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m., May 20, 1881, for constructing dam of brush and stone at Louisiana, Mo.

Number.	Names of bidders.	Residence.	4,000 cubic yards stone.		3,500 cubic yards brush.		Aggregate.
			Price per cubic yard.	Amount.	Price per cubic yard.	Amount.	
1	A. J. Whitney	Keokuk, Iowa	$2 00	$8,000 00	$1 30	$4,550 00	$12,550 00
2	H. S. Brown	Hamilton, Illinois	1 95	7,800 00	1 30	4,550 00	12,350 00
3	W. A. & J. C. Patterson	Keokuk, Iowa	1 93	7,720 00	1 28	4,480 00	*12,200 00

*Contract awarded.

SURVEY OF THE MISSISSIPPI RIVER AT LOUISIANA, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 22, 1880.

GENERAL: I have the honor to present the following report and accompanying map of the survey of the "Mississippi River at Louisiana, Mo.," made in accordance with your instructions dated June 17, 1880.

The report includes a plan and estimate for the improvement of the river from the upper end of the city (including the harbor) to a point about $3\frac{1}{4}$ miles below the bridge, a total length of about 5 miles.

ABOVE THE BRIDGE.

Through navigation above the bridge is good and the approach to the draw, formerly somewhat difficult, is now much improved. There appears, however, a tendency to the formation of sand-bars in front of the city (see map), and the landings are gradually becoming obstructed by sand deposits. To prevent the further formation of such deposits, and remove those already made, the construction of a spur-dam is recommended in accordance with the general plan for improving the river, extending from the Illinois shore out to the deep water of the channel, as shown on the map.

This dam, by more closely confining the channel to the Missouri shore, will have a beneficial result.

Another question occurs: the ferry crossing has by degrees become more and more obstructed until at present the route is very circuitous. The ferry being an important factor in the prosperity of Louisiana, much interest in the matter has been shown, and a petition, of which the following is a copy, was presented to the honorable Secretary of War in December, 1879:

To the Hon. GEORGE W. MCCRARY,
Secretary of War of the United States of America:

We, the undersigned, citizens of Pike County, Missouri, river-men of Mississippi River, would respectfully represent that the dike built by the Chicago and Alton Railroad Company in the Mississippi River near the Illinois shore, opposite the city of Louisiana, has not been kept in that state of repair necessary to make it efficient for any of the purposes intended in the original construction thereof. The upper end, which is intended to turn the current, has become so low as to form no impediment to the course of the water, and the lower part has caused a very large bar to form both above and below the dike, so that the ferry-boat plying between the Illinois and Missouri shores can only cross by going 2 miles or more out of its course, and that at great risk to the boat, which has to pass twice under the railroad bridge and pursue a narrow and tortuous course in close proximity to large piles of stone thrown in the river by said railroad company to protect their bridge.

We would further show that unless some action is taken by the government the channel of the river itself may be very seriously affected by the condition of the dike and the obstructions placed in the river by said railroad company.

We would respectfully petition that you take such appropriate action in the premises as will remove all causes of complaint and occasions of damage, and all hinderances to inter-State commerce by means of the ferry now in operation at said city of Louisiana.

Signed by J. N. Montgomery, pilot; Frank Burnett, United States steamboat inspector, and many others.

The above petition was referred to me by letter of the Chief of Engineers, of December 27, 1879, and I made the following report in regard to it:

[UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 2, 1880.

GENERAL: As instructed in an indorsement, dated Office Chief of Engineers, December 27, 1879, on a letter addressed to the honorable Secretary of War by the

Hon. F. M. Cockrell, dated December 18, 1879, and referring to a dike in the Mississippi River opposite Louisiana, Mo., I have the honor to report as follows:

This dike was built by the Louisiana and Missouri River Bridge Company in accordance with the recommendations of the Board of Engineers to whom were referred the plans and proposed location of the Louisiana bridge.

The dike was built to straighten the channel and remove a sand-bar above the draw of the bridge. A comparison of the maps made in 1876 and 1878 shows that the dike, by confining the channel to the Missouri shore, has caused a part of the bar to be washed away, and that the channel above the draw of the bridge has been improved, though additional works are still required to render the passage through the draw of the bridge easy. The dike has held a large sand-bar above and below it, as was expected. For general purposes of navigation this is very desirable, but, as stated in the petition and shown on accompanying tracing, the ferry route has been lengthened out and made troublesome by the crest of the bar, which is gradually moving down stream.

Capt. B. D. Greene, Corps of Engineers, inspected this dike last month. He found it had settled in some places and required numerous repairs.

Though the deep pockets near Illinois shore and close up to the dike may sometime cause trouble, he does not consider that there is any immediate danger of any portion of the dike being carried away. The improvement of the river necessitates the construction of dams which will confine the low-water channel and hold the sand-bars. Where such works cause a shoaling, or form bars which interfere with former landings, the only remedy to be suggested is to move the landing out to deep water and construct a causeway by which it may be reached during low-water. The trouble of the ferry company at Louisiana might be overcome by converting the railroad dike into a causeway, but considering the condition of the dike and the manner in which it was built, it would be undoubtedly better to construct a causeway on the line shown in red on the accompanying tracing, which is the approximate position of a spur-dam included in the plans for the general improvement of the river in the vicinity of Louisiana. To build an ordinary spur-dam of the required length and height would cost about $8,000.

To build this dam in the form of a causeway 15 feet wide on top and 5 feet above low-water would exceed the cost of the spur-dam about $8,000.

The papers referring to this matter are returned herewith, as requested.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

BELOW THE BRIDGE.

The channel within the limits of the map is moderately deep, although somewhat crooked, especially just below the bridge. About 2,000 feet from the bridge, and nearly in the center of the channel, is a sunken rock barge. This should be removed. There appears to be a tendency of the channel to turn over to the Illinois shore above sand-bar "A," and as this would render the channel more crooked and liable to obstruction by sand-bars, this tendency should be prevented. Farther down, at Brokau Island, steamboats now run the western channel known as Krider's Bend, and it is very desirable that the channel be maintained on this side, and not allowed to change as heretofore from one side of the island to the other, navigation being always obstructed while such changes are going on.

For carrying out the improvements above suggested, I would respectfully present the following

PROJECT.

1. The construction of a spur-dam (No. 1) from the Illinois shore, starting from a point about 600 feet above the old dike and extending out to the deep water of the channel, a distance of 1,750 feet, its crest to be at an elevation of 4 feet above extreme low-water. This dam, by materially contracting the water-way, will hold the channel on the Missouri shore, remove the bars now forming in front of the city and along the landings, and prevent further deposits of sand or mud.

2. The removal of the sunken rock barge in the channel below the bridge.

3. The closing of Buffalo Island Chute near its head by a dam (No. 2), with its crest at an elevation of 4 feet above low-water.

4. The construction of a spur-dam (No. 3) from the Illinois shore to sand-bar A, about 1,800 feet in length, to prevent a diversion of the channel to the eastern shore.

5. The protection of the eastern shore of Buffalo Island for a distance of about 1,800 feet.

6. The construction of a closing dam (No. 4) across Brokau Chute, in order to maintain the channel in Krider's Bend, where it now is, and where it is very desirable that it should remain.

This dam will be 1,150 feet long, and have its crest at an elevation of 4 feet above low-water.

ESTIMATE.

Dam No 1, above bridge:		
4,064 cubic yards rock, at $1.50	$6,096	
3,467 cubic yards brush, at $1	3,467	
		$9,563
Removal of rock pile:		
Five days' hire of dredge, &c,, at $100		500
Dam No 2, Buffalo Chute:		
948 cubic yards rock, at $1.50	1,422	
625 cubic yards brush, at $1	625	
		2,047
Dam No. 3, Illinois shore to sand-bar A:		
6,630 cubic yards rock, at $1.50	9,945	
6,285 cubic yards brush, at $1	6,285	
		16,230
Shore protection, Buffalo Island:		
3,888 cubic yards rock, at $1.50	5,832	
2,592 cubic yards brush, at $1	2,592	
		8,424
Dam No. 4, Brokau Chute:		
6,546 cubic yards rock, at $1.50	9,819	
6,225 cubic yards brush, at $1	6,225	
		16,044
Engineering and contingencies, say		2,192
Total estimate		55,000

To construct a causeway suitable for teams, 15 feet wide on top and at a height of 6 feet above low-water, which would serve the same useful purpose as Dam No. 1, and also furnish a good landing at its outer end for the ferry-boat, thus obviating the trouble, to which the ferry is now exposed, would cost $17,000, or about $7,500 in excess of the cost of Dam No. 1. Should it be thought proper to build this causeway, the amount of $7,500 should be added to the foregoing estimate.

To repair the old dike would require about 3,000 cubic yards of rock, and would cost about $4,500.

COMMERCIAL STATISTICS.

Louisiana, Mo., has a population of about 5,000, and is the principal city of Pike County. It is the second city of the State in the manufacture of tobacco, being surpassed in that respect by Saint Louis alone.

The following statement shows the volume of business done at Louisiana in 1880:

	Value.
Tobacco manufactured	$500,000
Lumber	300,000
United States stamps used	150,000
Banks	5,000,000
Dry goods and groceries	1,000,000

	Value.
Flouring-mills	$150,000
Other business	300,000
Total	7,400,000

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

U 17.

IMPROVEMENT OF GALENA RIVER AND HARBOR, ILLINOIS.

The original project for this work is given in Report of Chief of Engineers, 1874, Part 1, page 289.

Under contract with Whitney & Son, dated August 27, 1879, work was commenced April 17, 1880, and carried under various difficulties until July 20. Subsequent to the closing of this contract, the stage of water being particularly favorable, an informal agreement was made with Whitney & Son and H. S. Brown & Co., and all available dredges set to work. By the middle of August work was suspended, the water having fallen to such an extent as to make the work difficult and expensive. The harbor of Galena, including the "turning place," was dredged to the grade of low-water, the material being deposited on the banks in the vicinity, and a single cut was made (with double cuts at the ends) from about three-fourths of a mile above the cut-off to within about 3,000 feet of the woolen mill, when work was suspended in 1879.

When the above 3,000 feet of cut is made, which work is now being done, there should exist a channel from the Mississippi River to Galena of from 3 to 4½ feet depth at low-water and from 30 to 100 feet wide, but the softness of material and crowding of loaded boats along the edge of the channel have in places no doubt greatly reduced the depth, and some cleaning up must be done after the channel is cut through.

A new contract has been made with Whitney & Son, under appropriation of March 3, 1881, and dredging was commenced about June 1. The length of tow in the Galena River varies with the stage of water from 1 to 8 miles and the cost of work varies in proportion, and it is therefore very desirable that, with the dredges now in use, the work be done at high stages, which will permit depositing material in side sloughs and pockets near at hand. The estimated cost of the improvement of Galena River and harbor was $400,000, and to carry on this work successfully appropriations should be large enough to justify a contractor in procuring special machinery for removing and depositing of material. The material of the banks and bottom being very soft, it is probable a permanent improvement may yet require certain portions of the river to be sheet-piled. I would respectfully suggest an appropriation of $50,000 for fiscal year ending June 30, 1883.

Summary of work to date.

Year.	Working season.	Excavation, in cubic yards.	Amount.
1878	September 16 to November 17	29,506	$7,095 05
1879	April 3 to August 1	98,921	23,195 28
1880	April 17 to August 13	89,125	19,466 42
1881	June 1 to June 30	7,843	2,123 05
	Total	225,395	51,879 80

ABSTRACT OF APPROPRIATIONS.

By act approved June 18, 1878	$30,000
By act approved March 3, 1879	12,000
By act approved June 14, 1880	12,000
By act approved March 3, 1881	12,000
	66,000

Money statement.

July 1, 1880, amount available	$15,642 95	
Amount appropriated by act approved March 3, 1881	12,000 00	
		$27,642 95
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		11,230 85
July 1, 1881, amount available		16,412 10
Amount (estimated) required for completion of existing project		334,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

COMMERCIAL STATISTICS.

Volume of mercantile transactions	$1,590,000
Manufactures, value	1,338,379

Abstract of proposals received and opened by Capt. A. Mackenzie, Corps of Engineers, Rock Island, Ill., at 2 o'clock p. m. May 20, 1881, for dredging in Galena River, Illinois.

Names of bidders.	Residence.	For depositing material at a distance not exceeding 8½ miles.	For depositing material at a distance not exceeding 7 miles.	For depositing material at a distance not exceeding 6 miles.	For depositing material at a distance not exceeding 5 miles.
		Per cubic yard.	*Per cubic yard.*	*Per cubic yard.*	*Per cubic yard.*
Whitney & Son	Keokuk, Iowa	$0 49	$0 42	$0 37	$0 32
H. S. Brown	Hamilton, Ill	50	44	36	32

Names of bidders.	For depositing material at a distance not exceeding 4 miles.	For depositing material at a distance not exceeding 3 miles.	For depositing material at a distance not exceeding 2 miles.	For depositing material at a distance not exceeding 1 mile.	Aggregate.
	Per cubic yard.	*Per cubic yard.*	*Per cubic yard.*	*Per cubic yard.*	
Whitney & Son	$0 28	$0 25	$0 22	$0 19	$2 54*
H. S. Brown	28	26	23	20	2 59

*Contract awarded.

U 18.

IMPROVEMENT OF CUIVRE RIVER.

The original project for this work contemplates the improvement of Cuivre River and Cuivre Slough so as to afford a minimum depth of 2 feet at extreme low-water, by—

1. The excavation by dredging of a channel 80 feet wide through the four shoals in the main river.
2. The excavation by dredging of a channel 100 feet wide through the three sand-bars in Cuivre Slough.
3. The construction of a dam across the lower part of Cuivre Slough.
4. The removal of snags and overhanging trees.

The original estimate for the entire work is $30,000.

DREDGING.

A dredge and plant were put in the river on May 7, 1881, under agreement with H. S. Brown & Co.; work was continued until June 15, when the allotment made for dredging was expended. A channel 80 feet wide was made through Shelton Bar and a channel of 60 feet through Morrison's Bar. A cut 40 feet in width was made through a portion of Seed Tick Island Bar and 20 feet wide over the entire length.

The material removed consisted of a mixture of sand, clay, and gravel, easily taken up by the dredge, and the total amount excavated was 19,319 cubic yards. Navigation has been much improved by this work as far up as Monroe, about 13 miles from the mouth of Cuivre Slough.

SUMMARY OF WORK MAY AND JUNE, 1881.

11,200 cubic yards material dredged, at 25 cents	$2,800 00
8,119 cubic yards material dredged, at 20 cents	1,623 80
Six hours' snagging, at $12	72 00
	4,495 80

REMOVAL OF SNAGS, IMPENDING TREES, ETC.

For this very necessary work the snag-boat General Barnard, with a large force of axmen, was detailed, and entered the river May 30, 1881, remaining until June 18. The banks of this narrow stream, as well as of Cuivre Slough, were lined with overhanging trees on both sides for the greater part of the distance from the mouth to Chain of Rocks.

SUMMARY OF OPERATIONS OF SNAG-BOAT GENERAL BARNARD IN CUIVRE RIVER MAY AND JUNE, 1881.

Snags removed	94
Leaning and impending trees pulled back	30
Leaning and impending trees felled	13,485

There still remain a few snags which the Barnard was unable to remove on account of high-water. It is proposed to take these out at some time during the season when the water is at a suitable stage.

ABSTRACT OF APPROPRIATIONS.

By act approved June 14, 1880	$2,000
By act approved March 3, 1881	5,000
Total	7,000

Money statement.

July 1, 1880, amount available	$2,000 00	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$7,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	6,371 46	
July 1, 1881, outstanding liabilities	256 04	
		6,627 50
July 1, 1881, amount available		372 50
Amount (estimated) required for completion of existing project		23,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		23,000 00

COMMERCIAL STATISTICS.

No reliable information in regard to the quantity of shipments could be obtained, the greater part of the grain, &c., now seeking a market by rail. The steamer Dora has made, during the spring and summer of 1881, weekly trips to Chain of Rocks, receiving at that point from two to ten car-loads at each trip. The country tributary to the river is thickly settled and in a high state of cultivation, the products being wheat, corn, hay, tobacco, and fruit. Coal and iron abound in Lincoln County.

APPENDIX V.

IMPROVEMENT OF THE DES MOINES RAPIDS OF THE MISSISSIPPI RIVER AND OPERATING THE CANAL.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 28, 1881.

GENERAL: I have the honor to transmit herewith my annual report of operations for the improvement of the Des Moines Rapids of the Mississippi River, and operating and maintaining Des Moines Rapids Canal.

The report of the works temporarily under my charge during a part of the year will be made by Maj. J. A. Smith, Corps of Engineers.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

IMPROVEMENT OF DES MOINES RAPIDS, MISSISSIPPI RIVER, AND OPERATING THE CANAL.

The work has consisted of the removal of rock from river channel between Nashville and Montrose, by means of a steam drilling scow and dredge; the construction of timber cribs at the entrance to canal; repairs to steam drilling scow, dredge, and flats; grading and completing lock grounds; operating canal, including dredging and repairs.

CHANNEL EXCAVATION.

Steam drilling scow.—The very high stage of water in the river alluded to in the last annual report continued during a part of the month of July, and prevented any work being done until the 15th instant. Advantage was taken of this enforced cessation of work to make some necessary repairs to the steam drilling scow. On the 15th of July, the work of drilling and blasting rock in river channel above the Montrose Chain was resumed, and continued at this point until its completion, October 14.

On October 15, the drilling scow was moved down to a point just at the foot of the chain, where work continued up to November 17, when running ice and the freezing of the dynamite used for blasting obliged its discontinuance.

The drilling scow was towed down the river and laid up in the canal for the winter, slight repairs being made to the machinery during the time the boat was laid up. The severe and prolonged winter, and the unusually high-water which ensued, prevented the accomplishment of any work in the river until May 17, when the drilling scow was towed to the position occupied at the time of the cessation of work in the fall, and proceeded with the work of drilling and blasting rock. The work at this point was completed and the drilling scow then proceeded to drill and blast several small patches of rock inside the line of the old coffer-dam, which had been left unfinished at the time of the abandonment of work in the dam, February 24, 1876.

The method of conducting the work done by the steam drilling scow has been fully described in the annual report for the fiscal year ending June 30, 1880. The same general plan of operations was carried on during the year just passed. The progress of the work, however, was greatly interrupted by the causes above alluded to, viz, the early, severe, and prolonged winter, and very high water. The reefs which were drilled and blasted were situated on both sides of the old natural channel, and thus in close proximity to the course of passing steamers and rafts. Owing to this fact the drilling scow was frequently delayed from being obliged to move out of the way to avoid collision.

Herewith is appended a summary of work done and material used by the steam drilling scow for the fiscal year ending June 30, 1881:

Number of holes drilled	2,531
Total depth in feet drilled	7,097
Pounds of No. 2 dynamite used	4,484
Number of fuses used	2,565
Length in feet of 1½-inch octagonal steel used	25
Area of surface drilled over in square feet	37,308
Area made available as channel in square feet	69,560
Number of cubic yards blasted	*1,826

Steam dredge.—The steam dredge belonging to this improvement recommenced the work of removing blasted rock from river channel August 9, 1880, and up to November 17, operated at a point just above the Montrose Chain. On the 17th, it was found to be impossible to proceed with the work on account of running ice, and the dredge and flats were towed into the canal and laid up for the winter. The same causes heretofore alluded to as operating to prevent the use of drilling scow, also prevented the work of dredging. On the 31st of May, 1881, the dredge was taken to Montrose and commenced the removal of rock in river channel just below the Montrose Chain, and continued working at this point up to the close of the fiscal year.

The dredged material was placed, as heretofore, in piles 50 feet west of the channel line, making extensions of the rock piles formed at the time of excavation in the Montrose coffer-dam, 1875–'76. Some of these rock piles have been protected by the construction of timber cribs at the head of the piles. Removed blasted rock, 1,482.5 cubic yards. The cost of this work is somewhat over the estimate, on account of the necessity of frequent moving to escape collision with steamers and rafts, and also on account of the swiftness of the current.

TIMBER CRIBS AT ENTRANCE TO CANAL.

During the winter a force of mechanics and laborers was employed in constructing two timber cribs at the entrance to guard-lock.

*The number of cubic yards blasted in above table refers to rock above grade. Considerably more was actually blasted in order to insure grade.

These cribs are each 18 by 18 feet, their height above the grade-plane of excavated channel being 16.667 feet, or high-water mark.

These cribs are located on the east side of channel, on a line projected from the tangent point of curve on pier-head of guard-lock to a point on the channel line 300 feet above; so that the inner line of the cribs forms a small angle (7° 39′) with the line of direction of the lock. The distances at which these cribs are located above the pier-head are, respectively, 30 and 98 feet.

These cribs were partly constructed on the ice which then covered the river, and they were afterwards launched, placed in exact position, and the work of building continued until a sufficient height had been secured to bring the crib above the water-line when settled in place. The cribs were then weighted down, filled with rock, and the building completed. The bottom courses of the cribs are of 8 by 8 inch and 8 by 12 inch timber, securely fastened together with drift-bolts of $\frac{5}{8}$-inch round iron.

The remainder of the crib is built up of courses of 2 by 8-inch and 2 by 12 inch plank spiked together, covered on the front with 2 by 12 inch plank placed vertically, and further protected on the front and up stream side by boiler-plate iron at about the ice-line.

Braces cross the interior of the crib from side to side in each direction on every alternate course of six planks each, and iron straps assist in binding the whole together.

The rock used in filling the cribs was partly hauled in sledges on the ice from the waste-pile of coffer-dam No. 2, the balance being put in from flat-boats after the river opened in the spring. These cribs are designed to alleviate the trouble which at times is experienced by boats making the entrance to the lock. The velocity of the current which sweeps around the pier-head tends to draw the steamboats out of position, and these cribs, acting as guides, will, it is hoped, make the entrance less difficult.

REPAIRS TO DREDGE, FLAT-BOATS, ETC.

During the season of 1880, a force of carpenters and painters was engaged in restoring to its original condition the cabin of the dredge, which was destroyed by the fire occurring June 27, 1880, as described in the last annual report. At various times, during the working season and during the winter, necessary repairs were made; the crane, dipper handle, and spuds were repaired or replaced as was found to be necessary. Previous to the drainage of the canal in the winter, temporary cribs of blocking were placed in position to support the dredge when the water should be drawn off. When this drawing-off occurred, the dredge was, in effect, dry-docked, so that the entire hull could be readily examined and repaired. New plank and timbers were inserted in the bottom and sides where required. New leaders for the spuds were fitted and bolted in place, and the forward bulkhead strengthened by knees, bolted through the kelson timbers, while a new oak nosing was placed entirely around the hull on a level with the deck, the old nosing having been entirely worn out in service. A new floor was placed in the coal bunkers, and the entire hull carefully caulked. The fire-box of steam-boiler was found to need considerable repairs, which were accordingly made during the time the dredge was laid up in the winter.

Some of the flat-boats used to remove the dredged rock have been repaired and strengthened; additional bulkheads, extra deck planking, and new gunwales securely bolted; also new bottom plank being in-

serted where required. Slight repairs were also made on some of the flat-boats used on light service, and also on the small boats, from time to time as required.

GRADING AND COMPLETING LOCK GROUNDS.

A small force of mechanics and laborers was employed in finishing the grading and fencing and in building sheds for the storage of coal at each of the three locks. The regular canal hands have, whenever possible, been employed to do this work.

LAYING NEW RIPRAP FACE WALL.

Under this head no work was done for the fiscal year ending June 30, 1881.

OPERATING AND MAINTAINING CANAL.

The unusually high stage of water in the river, which was mentioned in the last annual report as occurring about the close of the fiscal year, continued throughout a portion of the month of July, and it was not deemed safe to reopen the canal for navigation until July 12. The canal continued in operation without delay or accident from this time, July 12, to November 19. When the water was sufficiently low to permit thereof, both sets of gates were allowed to stand open at the guard-lock. Such low-water periods occurred from August 12 to September 25, and from October 11 until November 17, when the gates were closed on account of heavy running ice.

The canal was closed for the season of 1880 on the 19th of November, ice having already formed on the river, and navigation having been entirely suspended above this point. During the winter and spring months the canal forces were employed in overhauling and making slight repairs to the gates and machinery. At the middle lock the steam-boiler flues were calked and carefully tested. The boiler was supplied with a wooden jacket covered with Russia sheet-iron, and a new door and frame for fire-box. The jackets which now incase the boilers at both the lower and middle locks have effected a considerable economy in the consumption of fuel; particularly is this the case when the fires are banked up and the engine standing still. On examination of the steam cylinder and chest of the pumping engine at middle lock, it was found necessary to replace them both, which was accordingly done. The chimney flues have been supplied with cast-iron doors, and frames inserted near the base of the flue, the object of this arrangement being to provide a more easy means of access to the flue for the purpose of removing the accumulations of soot.

During the winter advantage was taken of the abundant supply of ice which had formed in the canal to fill the ice houses at the three locks to their full capacity.

A partial break up of the ice in the river occurred on March 24, but a gorge formed soon after, and it was not until March 31 that the first steamboat of the season was enabled to reach Keokuk. The canal was opened for navigation for the season of 1881 on April 16. The stage of water in the river was so high, however, that both sets of gates at the lower lock were opened, and so remained until May 4. The water in the river continued to rise, and on April 18 had covered the lock walls. The highest point was reached on April 25, when the gauge showed a reading of 17.35 feet above low-water of 1864, being at this stage 1.55 feet

above the lock coping, entirely submerging the gates, portions of the machinery, and the greater part of the lock grounds.

The highest point reached during the past fiscal year was but two-tenths of a foot lower than that reported for the fiscal year ending June 30, 1880. During this excessive high-water the canal was temporarily closed, but was re-opened May 3. The lower lock gates having been closed, were operated in the usual manner from May 4 to 13, when, high-water recurring, the gates (both sets) were opened, and so remained from the 13th to 22d. On May 22 the gates at lower lock were closed, and thereafter to the close of the fiscal year, June 30, continued to be operated in the usual manner.

Owing to the unusually high stages of water which prevailed during a great part of the year, the number of lockages made have been much smaller than for the preceding year, as the rapids were navigable for a great portion of the year, and for heavy tows or lumber rafts a saving of time could be effected by going over the rapids, especially when going down stream. The season of navigation was also unusually short, closing early in the fall and opening late in the spring on account of ice. The manner in which the river and canal is now being utilized for the transportation of heavy freights in bulk, destined for foreign countries, has been exemplified by the passage of the steamer Victory through the canal, June 12, conveying a tow of barges carrying 30,000 bushels of grain, shipped on a through bill of lading from Saint Paul to Glasgow, Scotland, at the wonderfully low rate of 28 cents per 100 pounds.

DREDGING IN CANAL.

The steam-dredge, at such times as it could be spared from the work in river channel, has been employed in removing sand and mud from the bed of the canal, principally at points opposite Price's Creek, Lamalles Creek, and just below the guard-lock. About 9,003 cubic yards were removed, towed out in the river, and dumped in deep holes away from the channel. For the purpose of towing the dump-scows the steamer Cricket, belonging to Messrs. Wells, Timberman & Co., was employed.

Owing to scanty appropriations, the work of dredging in the canal has steadily fallen in arrears, and at the present time a very large quantity of material, washed into the canal by the creeks which drain therein, continues to obstruct the channel at various points.

The cost of finishing this work, as stated in my last annual report, was estimated at $96,580.50; this estimate was based on the cost of labor at that time. Since then the cost of labor has advanced from 15 to 30 per cent., and it has been found that the blasting and dredging in river channel has cost about 30 per cent. more than the estimate, which was occasioned by high-water and swift current, and the difficulty in using dumping scows for depositing material. For these reasons, it will be necessary to increase the above estimate to $110,000, which includes the building up of the lock walls. Of this amount $25,000 was appropriated by act of Congress March 3, 1881, leaving $85,000 to be appropriated. At the last session of Congress a provision was made in the river and harbor act for the future maintenance of the Des Moines Rapids Canal, by giving the Secretary of War authority to draw his requisitions upon the Secretary of the Treasury, from time to time, for the cost of operating and maintenance. This wise provision of Congress insures a sufficient and prompt supply of necessary funds.

The cost of operating and maintaining the canal for the fiscal year ending June 30, 1883, is estimated at $40,000.

Messrs. R. R. Jones and C. P. Comegys have performed their duties on the work and in my office with zeal and efficiency.

Messrs. O. S. Willey and Branch Railey were also prompt and faithful while connected with the work.

The following statement shows the business of the canal during the fiscal year:

Statement of steamboats, barges, rafts, &c., passed through the Des Moines Rapids Canal, from July 1, 1880, *to June* 30, 1881, *fiscal year ending Jnne* 30, 1881.

Month.	Steamboats.	Barges and flats.	Cargo.			Rafts.					Lockages at one lock.
			Passengers.	General merchandise.	Grain.	Rafts.		Logs.	Shingles.	Lath.	
	No.	*No.*	*No.*	*Tons.*	*Bushels.*	*No.*	*Feet.*	*Feet.*	*No.*	*No.*	*No.*
July	73	20	1, 906	6, 463	88, 333	....	.....	.....	.....	.....	124
August	148	52	2, 878	8, 027	92, 459	15	14, 643, 845	4, 630, 770	4, 797, 250	3. 545, 300	269
September	186	57	1, 629	8, 412	168, 637	7	4, 695, 367	1, 724, 960	1, 219, 250	499, 380	254
October	151	82	1, 134	9, 376	234, 366	17	15, 693, 587	3, 142, 680	4, 243 000	3, 838, 275	278
November	72	28	212	3, 146	94, 581	15	17, 053, 436	1, 515, 000	4, 385, 500	3, 774, 700	153
April	5	4	.....	75	.....	....	.....	.....	.....	.....	2
May	83	12	220	2, 813	169, 301	....	170, 000	.....	.....	.....	93
June	122	21	2, 024	6, 650	306, 415	....	.....	.....	446, 000	.....	166
Total ..	840	276	10, 003	44, 962	1, 154, 092	54	52, 256, 235	11, 013, 410	15, 091, 000	11, 657, 655	1, 339

The canal was closed 147 days, from November 19 to April 16, on account of cessation of river navigation, and 25 days, July 1 to 11 and from April 18 to May 3, on account of extreme high-water.

The boats and barges at work in the canal are not included in this statement, except in the number of lockages,

This work is located in the collection district of New Orleans. Saint Louis, Mo., is the nearest port of entry.

The following is a statement of the collections at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1881, viz:

Duties on imports	$1, 187, 328 31
Marine Hospital tax	12. 556 16
Fines	149 88
Inspection of steam vessels	5, 757 80
Licenses of vessel officers	7, 850 00
Storage	1, 819 74
Official fees	2, 666 55
Total	1, 218, 122 44

The estimated complete cost of this work as now being carried on is..	4, 450, 935 00
Cost of operating and maintenance of canal from August 22, 1877, to June 3, 1881	152, 282 83
Surplus remaining from appropriation for "operating, &c.," for year ending June 30, 1881	5, 282 17
Total	4, 608, 500 00
Total amount appropriated for all purposes up to June 30, 1881.	4, 523, 500 00
Amount required yet to be appropriated for finishing improvement....	85, 000 00

The cost of "operating, &c.," after the year ending June 30, 1881, is provided for by act of Congress, authorizing the Secretary of War to draw from the Treasury, from time to time, such amounts as may be needed.

Money statement.

July 1, 1880, amount available	$65,106 50	
Amount appropriated by act approved March 3, 1881	25,000 00	
Amount received from public sales	306 62	
		$90,413 12
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	40,562 62	
July 1, 1881, outstanding liabilities	2,899 14	
		43,461 76
July 1, 1881, amount available		46,951 36
Amount (estimated) required for completion of existing project		85,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		85,000 00

APPENDIX W.

PRESERVATION OF THE FALLS OF SAINT ANTHONY AND IMPROVEMENT OF THE MISSISSIPPI ABOVE THE FALLS—IMPROVEMENT OF CHIPPEWA AND SAINT CROIX RIVERS, WISCONSIN, AND OF MINNESOTA RIVER AND RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA—RESERVOIRS AT THE SOURCES OF THE MISSISSIPPI—CONSTRUCTION OF DAM AT LAKE WINNIBIGOSHISH.

REPORT OF CAPTAIN CHARLES J. ALLEN, CORPS OF ENGINEERS, BVT. MAJOR, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, Minn., July 20, 1881.

GENERAL: I have the honor to submit herewith the annual reports upon the works and surveys under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

W 1.

PRESERVATION OF FALLS OF SAINT ANTHONY, MINNESOTA.

The work during the fiscal year consisted principally in repairs to the apron and works for prevention of erosion of the ledge of rock below the angle on the east side.

The early part of the season was noted for heavy floods upon all the northern streams. The flood-water discharging at the Falls of Saint Anthony over the lower rolling dam—the latter a weir affording a width of water-way of less than 500 feet, and through an unbroken descent of nearly 40 feet, attained a power that only the firmest of structures could withstand. Damage from the flood was increased by great numbers of loose saw-logs which were run over the apron, notwithstanding the presence of the log-sluice constructed in 1879. To sheer logs into the sluice provided by law does not appertain to the United States Government.

Examinations made after the subsidence of the flood showed that great damage had accrued to the toe of the apron, and especially to the timber protection along the ledge of rock on the east side, just below the angle, and at the foot of the log-sluice. Soundings taken in August last showed

an average depth of 30 feet along a considerable portion of the toe of the apron, the greatest depth being on the easterly side.

Five heavy cribs were sunk along the face of the ledge below the angle and filled with stone, to serve as a foundation for the new work. One of them was 54 feet in length by 18 feet in width; one 22 by 18 feet; one 31 by 16 feet; one 45 by 16 feet, and one about 16 by 17 feet; the depths of the cribs varying according to the depth of water. The tops of these cribs were about 4 feet above low-water. The timber work, more or less, with loose stone, was then carried up so as to conform with the slope of the rest of the structure and decked with one layer of 8-inch timber and another of 4-inch plank. Tree-nails were used for the decking and drift-bolts for the cribs.

An additional crib, 75 feet long, and raised to the level of high-water, was placed in prolongation of the line of the above-mentioned cribs, in order to intercept an eddy making into a small bay, or recess, below the line of cribs, into which it was feared that, otherwise, loose logs might find their way, and injure the ledge.

The portion of the log-sluice projecting beyond the apron was removed, and a new foundation prepared by sinking a crib about 40 feet long by 16 feet in width. The lower end of the sluice was rebuilt upon this, and an additional crib about 20 feet in length by 16 feet in width was sunk, in order to prevent logs descending the sluice from being carried out of their proper path in a manner to damage the apron. The depth of water here was about 7 feet. While stripping off the damaged planking and timber, it was found that large numbers of saw-logs, which had passed over the falls, were buried under the work, they having been, doubtless, carried there by the vertical eddy.

There seems to be but one method to adopt, in order to effectually protect the works, and that is to sink a continuous, strongly connected throughout crib-work along the entire front of the apron, to serve as a buttress to that work and its flanks. The top of the crib-work is to be about 7 or 8 feet below low water, to be decked with heavy timber, and with a slope, if found desirable. The water at the falls passes over a ledge of limestone rock, underlaid by soft sandstone almost in a state of incipiency. A section of this ledge, taken along the axis of the stream, would show, at the lower point, a thickness of about 16 feet, and at the upper about 2 feet. The length of the section about 1,200 feet. This is all that is left to form the falls.

Nothing has occurred to cause any apprehensions as to the stability of the great concrete dike, finished in 1876. Recession of the crest of the falls, which the apron is designed to prevent would in time endanger the safety of the dike.

The present plan contemplated the stoppage of erosion of the limestone bed of the falls, by means of closing the enormous channels worn under the limestone ledge, and through the soft, underlying, incipient sand-rock, by filling of gravel, clay, &c., the construction of a concrete dike under the limestone ledge, reaching from extreme banks; remodeling and reconstructing the apron to prevent recession of the crest of the falls; rolling dams to maintain sufficient depth of water upon the bed of the falls, to prevent ice from adhering to the ledge in severe winters, and the protection of the toe of the apron.

During the month of April the necessary facts and testimony were placed at the disposal of the United States District Attorney, in order to enable him to apply for injunction from the United States court against running loose logs over or through the works, excepting through the

sluice. It is not known at the date of this writing that any injunction has resulted.

Congress, by act approved March 3, 1881, appropriated for—

Repairs and contingencies of public works at Saint Anthony's Falls, Minnesota: To meet repairs necessary, present and prospective, fifteen thousand dollars, which shall be available immediately after the passage of this act.

Steps were at once taken to strengthen the work against the expected high-water action, and bids were invited for timber, iron, &c., with which to commence work; the work to be by day labor and purchase of material in open market. Before, however, work could be commenced, the river broke up, ice moved in large masses, and this was succeeded by high-water. It is proposed to apply the appropriation to this work as soon as the river lowers sufficiently to enable full examination to be made.

To Mr. J. P. Frizell, assistant engineer, credit is due for the efficient work performed at the apron and ledge.

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenue collected during the fiscal year ending June 30, 1881, amounted to $8,351.53.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING THE FALLS OF SAINT ANTHONY.

By act approved June 11, 1870*	$50,000 00
By act approved March 3, 1871*	50,000 00
By act approved June 10, 1872*	50,000 00
By act approved March 3, 1873*	50,000 00
By act approved June 23, 1874	125,000 00
By act approved March 3, 1875	100,000 00
By act approved August 14, 1876	120,000 00
By act approved March 3, 1879†	10,000 00
By act approved June 14, 1880‡	10,000 00
By act approved March 3, 1881‡	15,000 00
Total	580,000 00
Original estimate for carrying out present project	529,726 31
Remaining to be appropriated	159,726 31

Money statement.

July 1, 1880, amount available	$10,444 35	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$25,444 35
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	10,291 33	
July 1, 1881, outstanding liabilities	140 86	
		10,432 19
July 1, 1881, amount available		15,012 16
Amount (estimated) required for completion of existing project		159,726 31
Amount that can be profitably expended in fiscal year ending June 30, 1883		50,000 00

COMMERCIAL STATISTICS, 1880.

Minneapolis (Falls of Saint Anthony) flour-mills and flour.

It is stated that no city in America has so large a capital invested in milling as Minneapolis.

During the year 1880 there was erected, by C. A. Pillsbury & Co., a new flour-mill, intended to be the most complete in the world, and which will, no doubt, have the

*These sums were used before the adoption of the present plan.
† For sluice-way through public works, &c.
‡ For repairs and contingencies, &c.

greatest capacity of any single mill, except one. It will have a capacity of 4,000 barrels flour each twenty-four hours.

The other mill (the Washburn A) has a capacity of 4,200 barrels daily, being the largest mill in America, and believed to be the largest in the world.

Minneapolis millers manufactured more flour in 1880 than any other city in America and will have a capacity the ensuing year double that of any other city. The three largest mills on the continent are located here, and three firms operate mills with a daily capacity of 17,200 barrels.

The total daily capacity of the mills at the Falls is about 25,000 barrels. The production in 1880 reached 2,140,840 barrels.

The following table gives the shipments and exports of flour for the years named:

Year.	Shipments.	Exports.
	Barrels.	*Barrels.*
1860	30,000	.....
1865	98,000	.....
1870	193,000	.....
1873	585,000	.....
1874	727,000	.....
1875	843,000	.....
1876	1,000,675	.....
1877	935,544	.....
1878	940,786	109,183
1879	1,551,789	442,598
1880	2,051,840	769,442

The growth of the manufacturing industries of Minneapolis is by no means confined to the flour and lumber interests.

The product of other establishments which are engaged in manufacturing for the trade foots up for the year 1880, $10,000,000.

COMPARATIVE STATEMENT FOR FIVE YEARS.

1880	$10,000,000 00
1879	6,950,725 00
1878	5,696,625 00
1877	4,802,300 00
1876	3,776,133 00

LOGS.

There were 3,110,000 feet of logs, valued at $21,770, run over the falls of Saint Anthony, destined for the boom below, during the season of 1880.

It is expected that there will be about 3,000,000 feet of logs, valued at $21,000, run over during the season of 1881.

LUMBER.

It is stated that there will be in running order the coming year seventeen mills with a capacity for manufacturing 254,000,000 feet during the season.

There was manufactured in the year 1880:

Lumber	feet..	195,452,182
Shingles		67,058,500
Lath		31,432,500

COMPARATIVE STATEMENT OF LUMBER PRODUCTION FOR FIVE YEARS.

1880	feet..	195,452,182
1879		149,754,547
1878		130,274,076
1877		129,676,000
1876		200,371,277

WATER POWER.

The permanent available water power of a stream is what it can furnish at the lowest stage of water, since mills constructed to use in excess of this amount are liable to interruptions.

The lowest volume of the Mississippi at Saint Anthony yet measured is 3,168 cubic feet per second, viz, on the 9th of March last. The greatest fall which any of the mills are now able to use is not over 50 feet. This gives something like 13,500 horse power as permanently available at Minneapolis.

The power could be greatly increased by the construction of storage-reservoirs to equallize the flow of water, and the construction of canals and races to utilize a larger fall.

W 2.

IMPROVEMENT OF MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

The work has principally consisted in the removal of bowlders from the channel, construction of a few wing-dams, and removal of snags and leaning trees, between Aitken and Grand Rapids, north of the line of the Northern Pacific Railroad.

The work was performed by day labor and purchase of materials as needed. The outfit consisted mainly of one derrick-boat, 40 by 20 feet, with capstan, crab, and heavy grapple; one quarter-boat, with accommodations for sixteen men and overseer; one scow, as tender; one large bateau; electric battery, dynamite, tools, &c. About 218 cubic yards of bowlders were removed and utilized in building dams; and thirty-eight snags and 9,035 "sweepers" and leaning trees removed. Stretch of river worked over, about 100 miles, of which about 40 miles were pretty effectually cleared. The improvement, thus far, has been of benefit.

Aitken, on the Northern Pacific Railroad, serves as a base of supplies for the extensive lumber camps throughout Northern Minnesota, and the supplies have been forwarded by river in flat-boats as well as by steamer. Steamboat navigation has been difficult on account of obstructions, as bowlders, snags, and leaning trees, and some sand and gravel bars. Generally speaking, the stream between Brainerd (this point also on the Northern Pacific Railroad, about 27 miles westerly from Aitken, and about 54 miles southerly from the agency and trading post of Leech Lake, Chippewa Indian reservation) and Grand Rapids, is a "better stream," with 3 feet depth at lowest water, more easily maintained than any portion of the Mississippi River above Saint Paul.

The report of Mr. R. Davenport, overseer in charge of work, herewith, gives the details of the work.

In the annual report for the fiscal year ending June 30, 1881, the improvement of the river above the Falls of Saint Anthony, was considered under the head of two partial projects; namely, of the stretch of river from Minneapolis to Saint Cloud, the original estimate for which was $144,667.50; and of the stretch from Conradi's Shoals (35 miles below Brainerd) to Grand Rapids, the original estimate for which was $54,127.50. These estimates were taken from the report under date of February 8, 1875, upon part of the Third Subdivision, Mississippi Transportation Route, in order to furnish estimates for the Senate Select Committee Transportation Routes to the Seaboard.

The division of the entire project, as noted in the last annual report, arose from the fact that work had been carried on, under appropriations, upon the extent of river between Minneapolis and Saint Cloud, a reach of river upon which there has been, for several years past, no navigation by boat worth mentioning, with no prospect of increase at present; while, between Aitken and Grand Rapids considerable navigation did exist. No work was done between Minneapolis and Saint Cloud during the fiscal year ending June 30, 1881.

The original estimate, then, of improvement of the two stretches of river would sum up $198,795.

Congress, by act approved March 3, 1881, appropriated for—

Improving Mississippi River above Falls of Saint Anthony, Minnesota, $10,000.

With this sum, and balance of funds remaining from former appropriations it is proposed to continue the work of improvement as begun, and also to remove some bowlders from the channel above Grand Rapids, such having been authorized.

The sum of $15,000 can be profitably expended during the fiscal year ending June 30, 1883, upon the river above Brainerd.

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenue collected for the fiscal year ending June 30, 1881, amounted to $8,351.53.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

By act approved June 23, 1874*		$25,000 00
By act approved August 14, 1876		20,000 00
By act approved June 14, 1880		15,000 00
By act approved March 3, 1881		10,000 00
		70,000 00
Original estimate for the work between the Falls of Saint Anthony and Saint Cloud, Minn		$144,667 50
Remaining to be appropriated		124,667 50
Original estimate for the work between Grand Rapids and Conradi's Shoals		54,127 50
Appropriations by acts approved—		
June 14, 1880	$15,000	
March 3, 1881	10,000	
		25,000 00
Remaining to be appropriated		29,127 50

Money statement.

July 1, 1880, amount available	$16,240 38	
Amount appropriated by act of March 3, 1881	10,000 00	
		$26,240 38
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	8,233 74	
July 1, 1881, outstanding liabilities	1,064 60	
		9,298 34
July 1, 1881, amount available		16,942 04
Amount (estimated) required for completion of existing project†		124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1883.		40,000 00
Amount (estimated) required for completion of project, viz, improvement between Grand Rapids and Conradi's Shoals‡		29,127 50
Amount that can be profitably expended in fiscal year ending June 30, 1883.		15,000 00

* Made and expended before the adoption of the present project.

† This is the project including only the stretch of river between Saint Cloud and Minneapolis, and is offered as an estimate in case the United States orders the continuance of work upon this piece of river.

‡ This project was adopted, following the appropriation of $15,000 made by act approved June 14, 1880.

REPORT OF MR. R. DAVENPORT, OVERSEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., June 30, 1881.

SIR: I have the honor to submit the following report of work done in improving the Upper Mississippi River between Aitken and Grand Rapids during the year ending June 30, 1881.

As instructed in your letter of August 12, 1880, I went to Aitken on the Northern Pacific Railroad and made arrangements for the construction of the boats required to do the work. Work was commenced on September 2, and the boats were completed and launched on 17th of the same month.

The outfit consists of one derrick-boat, 20 by 40 feet, fitted with capstan, crab, large grapple, &c; one quarter-boat, 9 by 57 feet, with cabin capable of accommodating sixteen men; one scow, 35 by 12 feet, used as a tender to the derrick-boat, and one 35-foot bateau.

COST OF CONSTRUCTION OF BOATS, MACHINERY, TOOLS, &C.

Derrick-boat and outfit	$831 78
Quarter-boat, camp equipage, &c	374 68
Scow	61 92
Bateau	25 00
Labor and supplies during construction of boats	358 81
Total	1,652 19

Work was commenced on the river about 100 miles above Aitken on the 27th of September, and between that time and the close of the season, about seven weeks, 218.3 cubic yards of bowlders were removed from the different rapids. The original instructions, letter of August 28, directed that a channel should be opened to a width of 60 feet, with depth of 3 feet at low-water, and all work has been done to that end, but it was afterward thought best, owing to the shortness of the season remaining, to remove the principal obstructions from all the rapids, as far as possible, thereby insuring navigation at any ordinary stage of water.

All stone removed has been used in building dams, where necessary, as shown on maps accompanying this report. Eighty dynamite cartridges were used in blasting; the cartridges were exploded by an electro-magnetic battery.

The distance worked over, from Pine Rapids to Island Rapids, is about 94 miles, the different rapids being from 6 to 20 miles apart.

From the commencement of the work up to the 9th of November, when the river closed, a small portion of the force had been employed in removing leaning trees, and after that time the entire force were so engaged until the 15th of February, 1881, when the work was discontinued, the great depth of snow that had accumulated by that time rendering further operations unprofitable.

Work was resumed at Grand Rapids on leaning trees and snags June 14, the water being still too high for work on the rapids, and from the commencement, September 27, to this date, June 30, nine thousand and thirty-five leaning trees and thirty-eight snags have been removed, the length of the river cleared being about 40 miles.

In connection with the other work I gauged the river at Grand Rapids and at the outlet of Sandy Lake River, making twenty-seven observations, showing the river to have a mean discharge at Grand Rapids of 1,467 cubic feet per second at a 0.9-foot stage above mean low-water, and 1,538 cubic feet per second at Sandy Lake Outlet at a stage of 0.4-foot above mean low-water.

DETAIL OF WORK ON THE UPPER MISSISSIPPI RIVER.

Bowlders removed.

	Cubic yards.
Pine Rapids	36.8
Crooked Rapids	87.5
Ox Portage Rapids	33.0
Noyes Rips	12.5
Sandy Lake Rapids	26.0
Moose Rapids	21.1
Island Rapids	1.4
Total	218.3

Leaning trees removed.

Date.	Locality.	Diameter 4 to 6 inches.	Diameter 7 to 9 inches.	Diameter 10 to 12 inches.	Diameter 13 to 15 inches.	Diameter 16 to 18 inches.	Diameter 19 to 21 inches.	Diameter 22 to 24 inches.	Diameter 25 to 27 inches.	Diameter 28 to 30 inches.	Diameter 31 to 33 inches.	Diameter 36 to 38 inches.	Total.
Sept., 1880	From Aitken 4 miles up river.	35	31	37	7	11	....	2	....	....	....	....	.....
Oct., 1880	At Crooked Rapids	43	39	64	17	4	...	....	....	....	....	....	.....
Nov., 1880	At Moose Rapids.....	.....	11	12	6	4	2	....	1	....	....	....	.....
Nov., 1880	At Island Rapids	.....	45	20	7	4	2	1	....	....	....	....	.....
Nov., 1880	From 4 to 8 miles above Aitken.	.....	782	462	109	89	19	13	3	....	....	....	.....
Dec., 1880	From 8 to 12 miles above Aitken.	261	525	463	150	110	26	13	1	5	1	3	.....
Jan., 1881	From 12 to 20 miles above Aitken.	1,422	726	628	182	265	60	36	10	11	1	4	.....
Feb., 1881	From 20 to 26 miles above Aitken.	629	282	306	106	107	27	20	2	1	....	....	....
June, 1881	From Grand Rapids 14 miles down river.	442	118	160	27	19	2	2	....	....	....	..	.....
	Totals.....	2,832	2,559	2,152	611	613	138	87	17	17	2	7	9,035

Snags removed.

Date.	Locality.	Diameter 4 to 6 inches.	Diameter 7 to 9 inches.	Diameter 10 to 12 inches.	Diameter 13 to 15 inches.	Diameter 16 to 18 inches.	Diameter 19 to 21 inches.	Diameter 22 to 24 inches.	Total.
June, 1881	From Grand Rapids 14 miles down river.	12	8	8	5	2	2	1	38

As a result of the improvement of the river, present and prospective, I can report the construction of two new steamboats, one above and one below Pokegama Falls; up to this time there had been but one boat on the river. The prospect of continuous navigation during the entire season and the large increase in lumbering on the upper river, rendered an increase in carrying capacity both desirable and remunerative. The present partial improvement, removal of 218 cubic yards of stone from the rapids, gave a fair navigable stage up to the close of the season, even during the extreme low-water of last fall.

The removal of leaning trees and snags has also materially improved the log driving.

I also respectfully submit maps of Pine, Crooked, Ox Portage, Sandy Lake, and Moose Rapids, showing the present condition, location of obstructions removed, dams built, &c.

Very respectfully, your obedient servant,

R. DAVENPORT,
Overseer.

Maj. CHARLES J. ALLEN,
Captain Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS, SEASON OF 1880.

Lumber, lath, and shingles manufactured at Minneapolis, Anoka, Saint Cloud, Clearwater, and Princeton.

Lumber	feet..	241,157,989
Shingles		88,446,125
Lath		49,423,100

The logs run during 1880, between Minneapolis and Sauk Rapids, amounted to 149,000,000 feet, valued at $1,192,000, and on the river above Aitken, they amounted to 77,000,000 feet, valued at $616,000.

Improvement of the
Mississippi River
Aitkin to Grand Rapids
1880.
Sheet No. 1

Profile. Center of Channel.

Elev. 89.476

Low Water. 1876.

Elev. 86.465

Clay and Boulders.

Map of Moose Rapids

So much as registered to low water.

Work Done in 1880
21.1 Cub Yds of boulders
removed from Channel.

Note
Continuous line = 3 ft low water curve.
Dotted line = outside of proposed 3 ft low water channel.
#. = Boulders removed from channel in 1880

Scale.

0 50 100 150 200 250

Section 23
Section 26

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Line of proposed channel.

3 ft. Curve

Line of proposed channel.

3 ft. Curve.

U.S.M.C.

0.0 to 2 ft of Water.

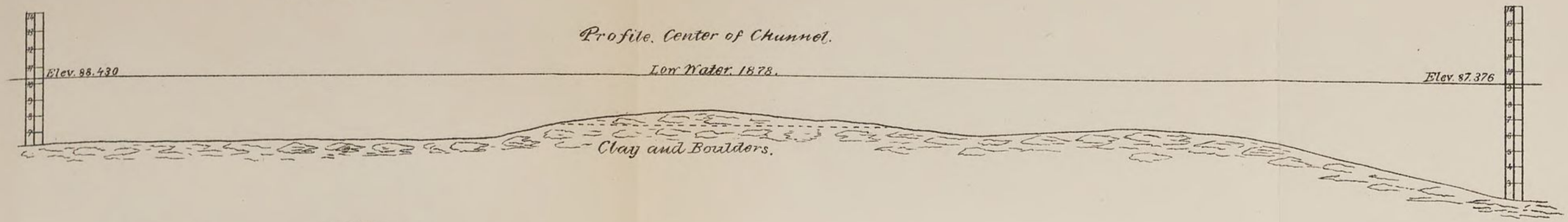
Boulder Reef

0.0 to 1.0 ft of Water.

Boulder Reef

U.S.M.C.

Improvement of the Mississinni River.
Aitken to Grand Rapids 1880.
Sheet No. 2



Map of Sandy Lake Rapids.

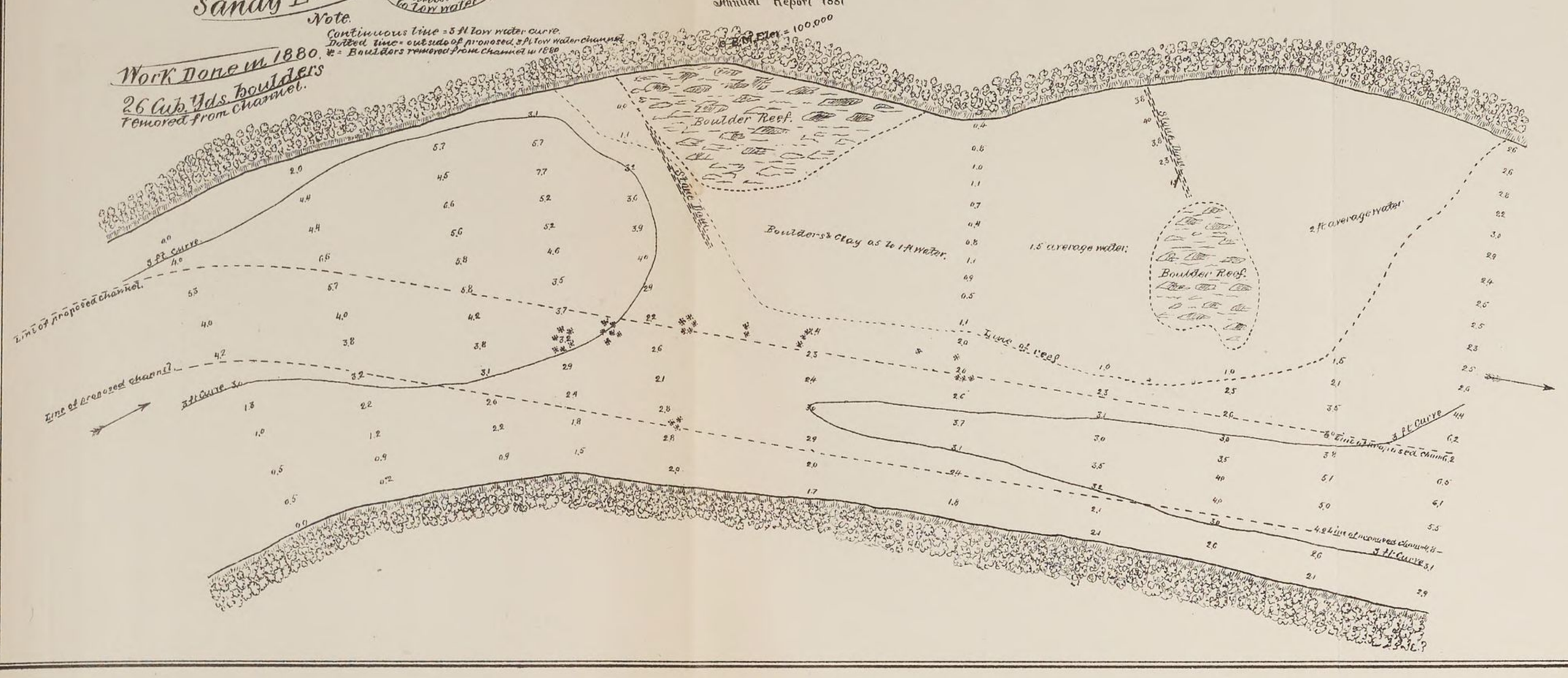
Soundings reduced to low water

Scale. 50' 0 50' 100' 150' 200' 250'

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Note.
Continuous line = 3 ft low water curve.
Dotted line = outside of proposed 3 ft low water channel.
= Boulders removed from channel in 1880

Work Done in 1880.
26 Cub. Yds. Boulders removed from channel.



Improvement of the Mississippi River
Aitken to Grand Rapids

Sheet No. 3 1880

Profile Center of Channel.

Low Water 1878.

Elev. 827.68

Elev. 816.07

Clay and Boulders.

Boulder Reef

Boulders

3 Ft. Curve

Line of Proposed 6 x 80 Channel.

Line of Proposed 5 x 80 Channel.

Map of Ox Portage Rapids
Soundings reduced to low water.

Work Done in 1880
33 Cub Yds Boulders removed from Channel.

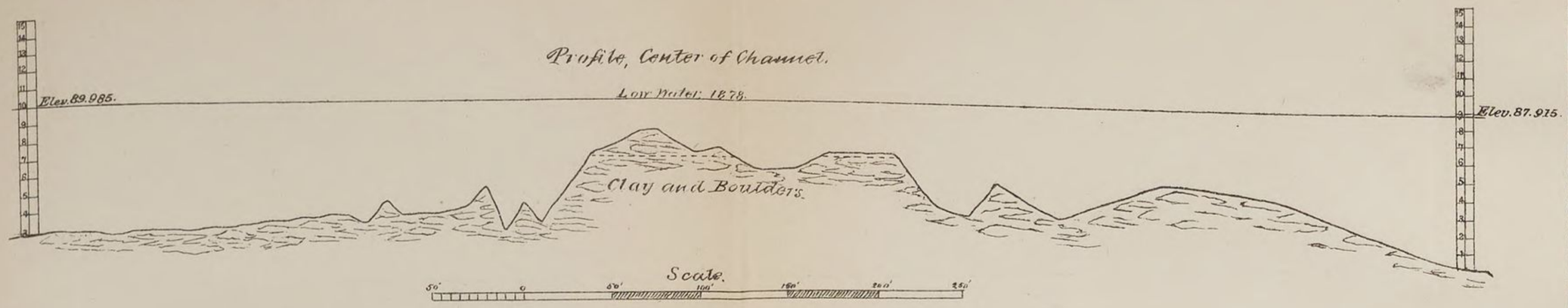
Note.
Continuous line = 3 ft low water curve.
Dotted line = outside of proposed 3 ft. low water channel.
⁂ = Boulders removed from channel in 1880

Scale.

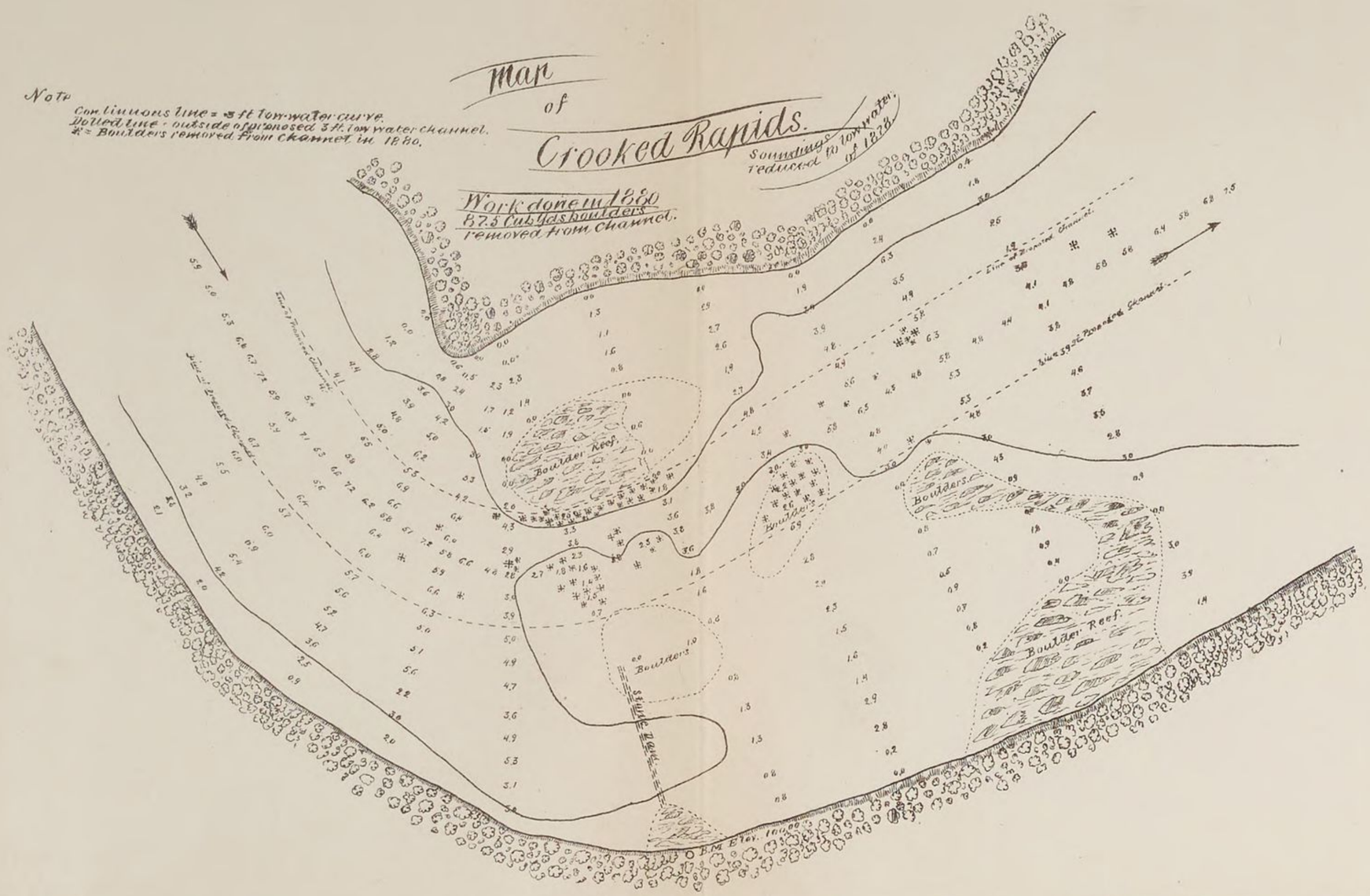
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Improvement of the
Mississippi River.

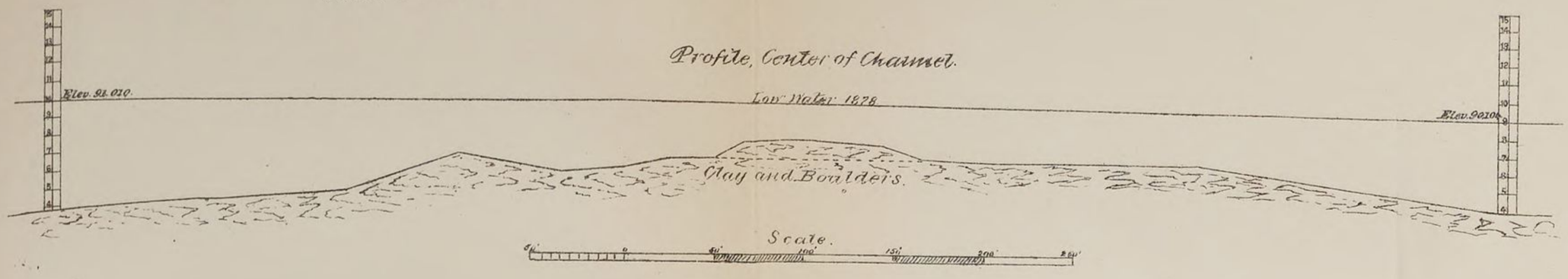
Aitken to Grand Rapids
1880.
Sheet No. 4



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Improvement of the
Mississippi River.
Aitken to Grand Rapids.
1880.
Sheet No. 5

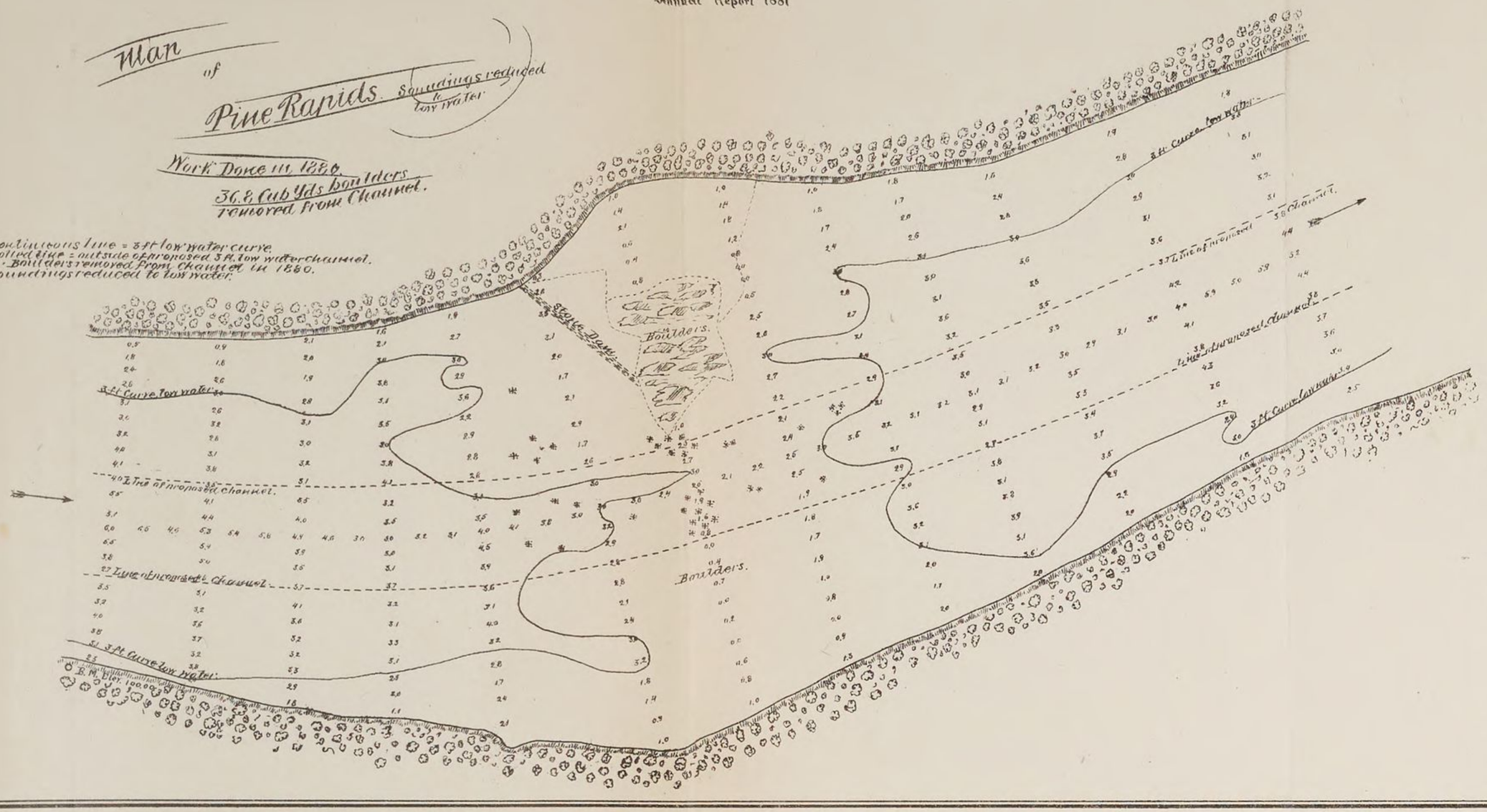


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Plan of Pine Rapids. Soundings reduced to Low Water.

Work Done in 1880.
36.8 Cub Yds Boulders removed from Channel.

Note.
Continuous line = 3 ft low water curve.
Dotted line = outside of proposed 3 ft. low water channel.
* Boulders removed from Channel in 1880.
Soundings reduced to low water.



Since 1878 there has been no use made of the river between Minneapolis and Saint Cloud for any purpose of commerce except the running of logs. In that year but one steamboat plied on the river above the Falls of Saint Anthony between the points named.

In the years 1855, 1856, 1857, 1858, 1859, before the railroad was built, steamboats were run between Minneapolis and Saint Cloud during high-water, as high as four being engaged in the trade at one time.

Between Aitken and Grand Rapids, Minn., there is now but one steamboat running. She has a capacity for carrying about 75 tons, and is provided with two barges, each with a capacity of about 45 tons, making her total carrying capacity about 165 tons.

During 1880 the amount of up-river business was about 7,874,250 pounds, consisting of feed and grain, blacksmith's coal, iron, hardware, groceries, provisions, salt, &c. She carried, also, during the season about 1,000 passengers.

The down-stream business consisted mostly of furs and snakeroot, which was valued at about $10,000.

There is now building at Aitken, to be finished by July 1, a smaller steamboat to run, also, between Aitken and Grand Rapids.

There is, also, a steamboat building just above Pokegama Falls, to ply between that point and Lake Winnibigoshish. It is expected this boat will be finished and ready for business on August 1.

W 3.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

The present project is given in the report of the Chief of Engineers for the fiscal year ending June 30, 1874, and based upon the results of a survey made during that year.

The object of the improvement is to connect with the improvement of the Mississippi below Saint Paul, so as to secure steamboat navigation up to the Falls of Saint Anthony.

The improvement of the Mississippi River above the Falls of Saint Anthony and from Saint Paul to the Gulf of Mexico has been adopted by Congress, but no appropriations have been made for improving the stream between Saint Paul and the site of the proposed lock and dam at Meeker's Island. The cost of lock and dam, as estimated in the report above referred to, is:

Masonry lock 300 feet long, 80 feet wide, with lift of 17 feet, about	$630,261 46
Timber dam	291,860 00
Total cost of improvement	922,121 46

Congress, by act approved July 23, 1868, made a grant of 200,000 acres of public lands to the State of Minnesota to aid the State in constructing the lock and dam in accordance with plan and estimate previously submitted.

By act approved March 3, 1873, Congress appropriated—

> For construction of the lock and dam on the Mississippi River at Meeker's Island, Minnesota, according to the surveys and plans of the War Department, twenty-five thousand dollars: *Provided*, That all rights and claims in and to the land-grant made to the State of Minnesota for the above work by act approved July twenty-third, eighteen hundred and sixty-eight, shall be fully relinquished to the United States before any of this appropriation is expended.

No work has as yet been done, the appropriation not being available, as the parties holding the land-grant have not made the required relinquishment. The State of Minnesota should annul the grant to the parties holding the land-grant and release the same to the United States. If it should be determined to commence the work and carry it on not

less than $300,000 should be appropriated for the work for the fiscal year ending June 30, 1883.

This work is in the collection district of Minnesota. Duluth, Minn., is the nearest port of entry, at which place the revenue collected for the fiscal year ending June 30, 1881, amounted to $8,351.53.

For commercial statistics, see Annual Report Improving Falls of Saint Anthony and Improving Mississippi River above Falls of Saint Anthony.

Money statement.

July 1, 1880, amount available	$25,000 00
July 1, 1881, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46
Amount that can be profitably expended in fiscal year ending June 30, 1883.	300,000 00

W 4.

IMPROVEMENT OF CHIPPEWA RIVER, WISCONSIN.

Work principally consisted in repairs to existing works at the mouth of the river and at Flower-Pot Island about 2½ miles above the mouth.

The rock covering of the east and west jetties had been carried away in several places by running ice, and some settling of foundation had likewise occurred from overfall according to the relative stages of water in the Chippewa and Mississippi Rivers.

These depressions were filled up and the work strengthened as far as could be done during the early part of last fall, difficulty in obtaining boats for transportation of material causing completion of repairs to be deferred until the winter when use could be made of the ice.

The Flower-Pot Cut-off Dam was commenced in 1879 as a temporary measure to prevent high-water from flanking the permanent Flower-Pot Island Dam. The high-water of June last (1880) had cut around the head of this cut-off dam so that it was necessary to extend it far enough to abut upon firm and higher grounds. About 400 feet of extension was accomplished during the fall and succeeding winter.

Congress, by act approved June 14, 1880, had provided for—

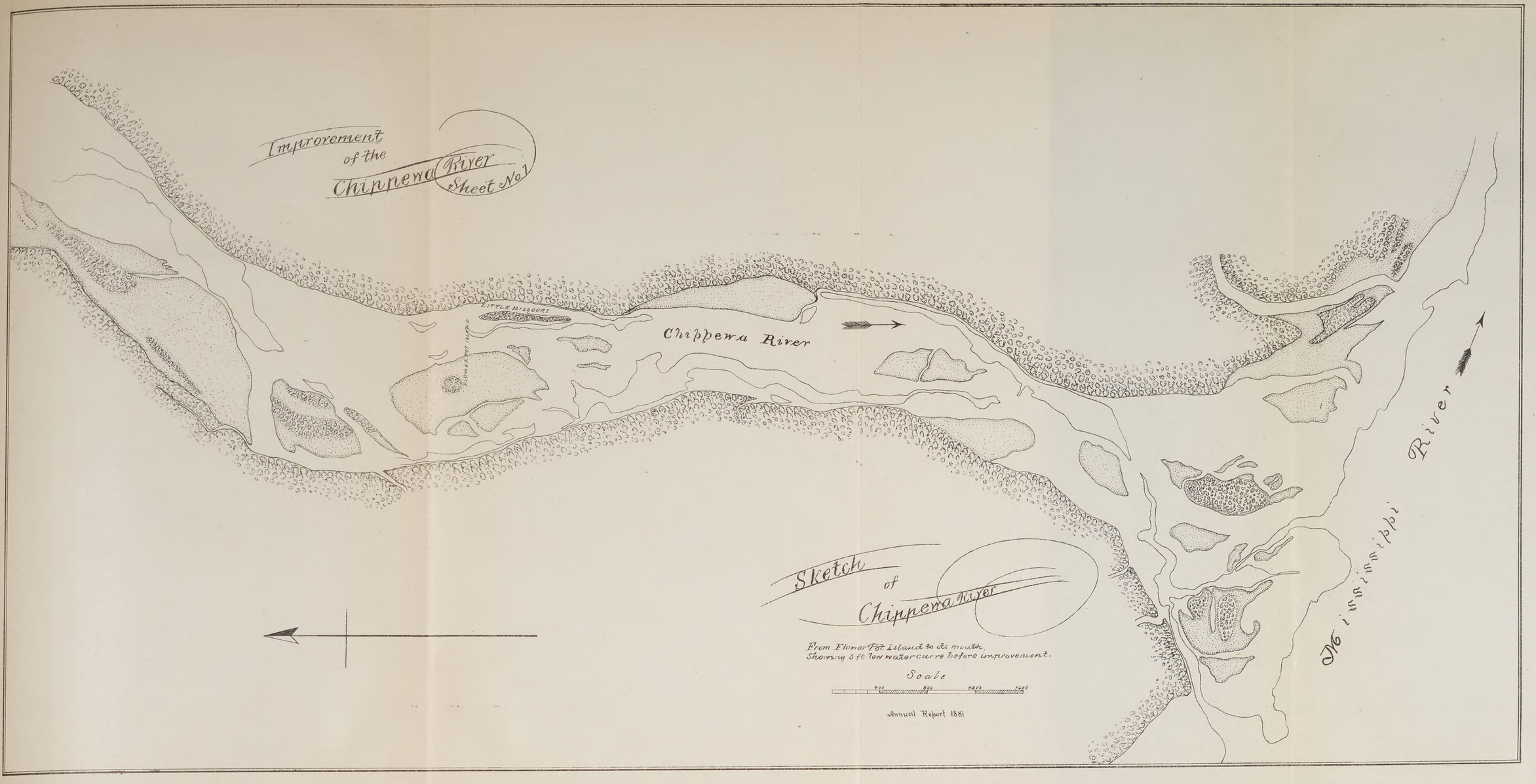
Improving the Chippewa River, Wisconsin; continuing the improvement, ten thousand dollars, but this sum is appropriated subject to the same conditions and limitations imposed by section one of the act approved March third, eighteen hundred and seventy-nine, for the improvement of rivers and harbors relating to said Chippewa River.

This appropriation became available too late in the season to let the work by contract to advantage, and it was decided to retain the bulk of the appropriation to add to the appropriation from the next Congress.

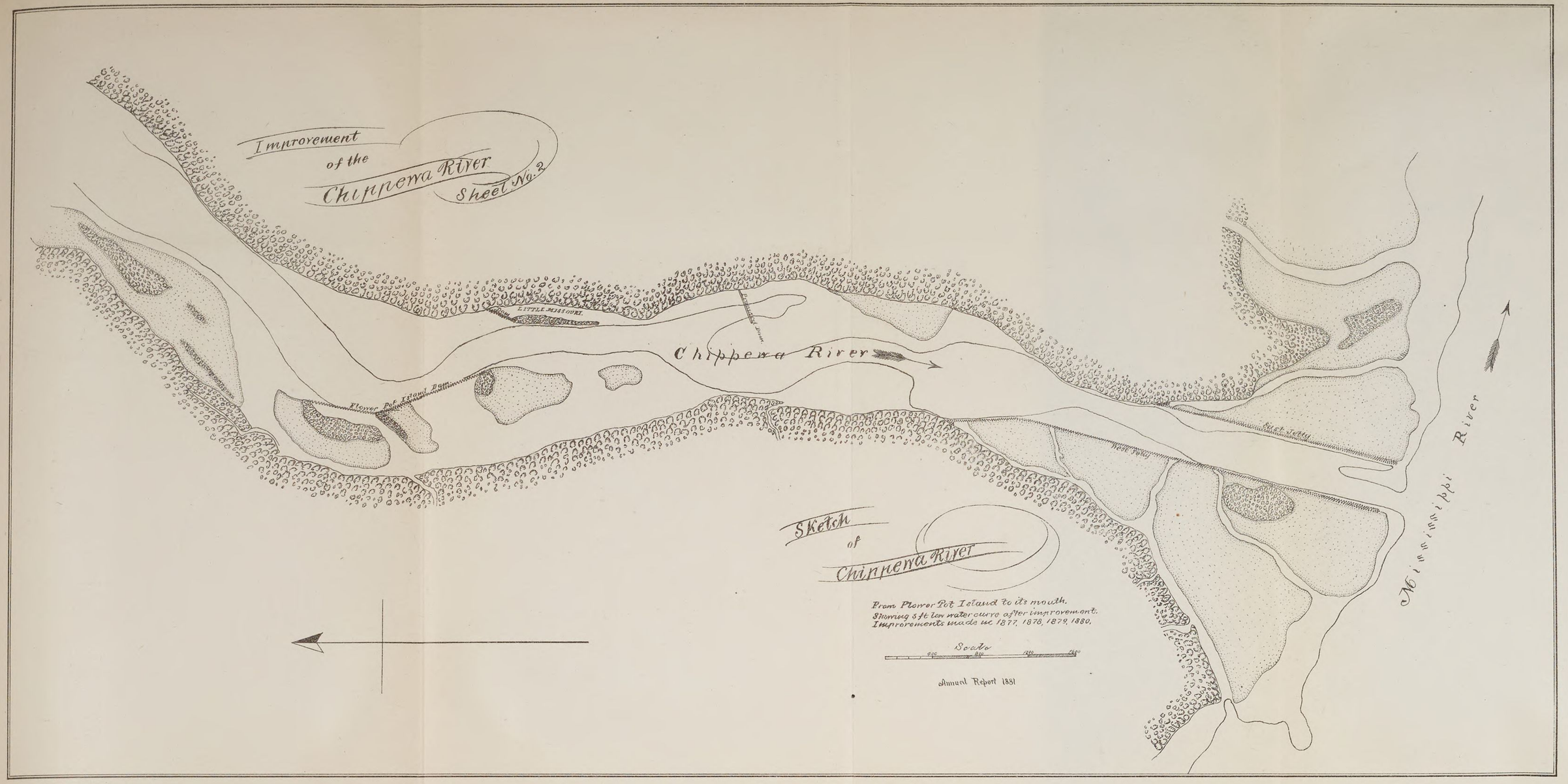
Congress, by act approved March 3, 1881, appropriated for—

Improving Chippewa River, Wisconsin, ten thousand dollars; but this sum is appropriated subject to the same conditions and limitations imposed by section one of the act approved March third, eighteen hundred and seventy-nine, for the improvement of rivers and harbors relating to said Chippewa River.

With this sum and the balance of funds from former appropriations it is proposed to make the necessary repairs to existing works and to continue the improvement as begun up stream from Flower-Pot Island so far as the funds will admit of. Some additional dams will undoubtedly be required between the head of the jetties and the works at Flower-Pot Island, the exact dimension and location of which can be better



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Improvement
of the
Chippewa River
Sheet No. 2
LITTLE MISSOURI
Chippewa River
Flower Pot Island Dam
Mississippi River
Sketch
of
Chippewa River
From Flower Pot Island to its mouth.
Showing 5 ft low water curve after improvement.
Improvements made in 1877, 1878, 1879, 1880.
Scale
Annual Report 1881

ascertained at the close of the present season than now. The additional works apparently most needed at present, and which it is proposed to undertake with the funds at hand are, at Dark Slough, Five Mile Bluff, Head of Battle Island, and in the vicinity of Plum Island.

Proposals were received and opened on the 1st June for performance of the work by contract, about $14,000 being allotted for the same.

The contract was awarded to Messrs. Simar & Morton, of Saint Paul, they being the lowest bidders. The contractors had, by the close of the month, assembled large quantities of brush and stone preparatory to placing it in position.

The present project for the improvement of the Chippewa River, based upon the original estimate of the engineer officer in charge, dated January 30, 1875, contemplated the removal of obstructions, natural and artificial, between Eau Claire and the mouth, at a cost of $139,892.50; of which amount $64,102.50 was estimated as the cost of protecting the five high sand-banks below Eau Claire, in order to prevent the material composing the banks from being carried down the river and into the Mississippi to form sand-bars in both streams. Only those familiar with this stream can appreciate the necessity for an adequate appropriation for the protection of the sand-banks on the Chippewa River.

If the work of improving this river is to continue, it is recommended that Congress be asked to appropriate the sum named for the protection of the sank-banks on the stream, and an additional sum of $25,000 to continue the work of building wing-dams and jetties; all of which can be profitably expended during the fiscal year ending June 30, 1883.

The result of the work to date has been in the highest degree beneficial to the navigation interests of the stream. Lumber rafts are no longer detained by bars at the confluence of the two rivers, a fact fully appreciated by those accustomed to detention before the work of improvement was commenced.

The work was well done under the local supervision of Mr. G. O. Foss, overseer.

This work is in the collection district of Minnesota. Duluth, Minn., is the nearest port of entry, at which place the revenues collected for the fiscal year ending June 30, 1881, were $8,351.53.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING CHIPPEWA RIVER, WISCONSIN.

By act approved August 14, 1876		$10,000 00
By act approved June 18, 1878		10,000 00
By act approved March 3, 1879		8,000 00
By act approved June 14, 1880		10,000 00
By act approved March 3, 1881		10,000 00
		48,000 00
Original estimate for carrying out existing project		139,892 50
Remaining to be appropriated		91,892 50

Of this amount $64,102.50 is estimated as the cost of protecting the five high sand-banks below Eau Claire.

Money statement.

July 1, 1880, amount available	$10,281 91	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$20,281 91
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	3,909 84	
July 1, 1881, outstanding liabilities	253 14	
		4,162 98
July 1, 1881, amount available		16,118 93

Amount (estimated) required for completion of existing project		$91,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1883:		
For protecting high sand-banks	$64,102 50	
For channel improvements	25,000 00	
		89,102 50

Abstract of proposals opened June 1, 1881, *by Capt. Charles J. Allen, Corps of Engineers, Saint Paul, Minn., for constructing dams and shore protection of brush and stone and some earth excavation for improvement of the Chippewa River, Wisconsin.*

Number.	Name and residence of bidders.	Name and residence of sureties.	Brush made into fascines or mats, putting in place, &c., 2,000 cords.		Stone in place, 4,500 cubic yards.		Earth excavation, 2,500 cubic yards.		Aggregate.
			Per cord.	Total.	Per c. yd.	Total.	Per c. yd.	Total.	
1	John Gage, Weaver, Minn.	W. H. Hopkins, Weaver, Minn.; S. J. Johnson, Weaver, Minn.	$4 49	$8,980	$1 75	$7,875	$0 20	$500	$17,355
2	Vine D. Simar, Saint Paul, Minn.; Walter S. Morton, Saint Paul, Minn.*	John W. White, Saint Paul, Minn.; Philip Reilley, Saint Paul.	2 99	5,980	1 47	6,615	06	150	12,745
3	Samuel McDonald, Casselton, Dak.	P. H. & J. M. Keenan, Casselton, Dak.	6 10	12,200	2 06	9,270	45	1,125	22,595
4	A. H. Truax, Hastings, Minn.	L. N. Countryman, Hastings, Minn.; S. H. Holmes, Hastings, Minn.	5 85	11,700	1 85	8,325	13	325	20,350

*Contract awarded.

COMMERCIAL STATISTICS, CHIPPEWA RIVER, 1880.

325,150,000 feet lumber, at $12 per M		$3,901,800 00
100,357,750 feet shingle, at $2.50 per M		250,894 37
74,945,150 feet lath, at $1.75 per M		131,154 00
2,423,940 feet pickets, at $10 per M		24,239 94
10,000 railroad ties, at 40 cents each		4,000 00
300,000,000 feet logs—Beef Slough, at $8 per M		2,400,000 00
		6,712,087 31
Cost of running out 325,150,000 feet of pine lumber, at 50 cents per M		$162,575 00

Steamboats commenced running April 6; steamboats ceased running to Eau Claire October 22; steamboats ceased running to Durand and Dunnville November 16.

Steamboats plying between Read's Landing and Eau Claire, Minnie Heerman and Ida Campbell; between Read's Landing and Dunnville, Phil. Scheckel; Wabash and Read's Landing and Durand, Monitor.

Over 2,000 raftmen and a quantity of freight went round to Eau Claire via Saint Paul by rail, owing to boats not being able to get to Eau Claire on account of low-water.

Under date of December 7, 1880, Ingram, Kennedy & Company, of Eau Claire, Wis., extensive dealers in lumber, lath, and shingles, say: "* * * Had it not been for the work done by the government at the mouth of the Chippewa, we could not have run our rafts or boats during the low-water of the past season, * * *."

Number of steamboats plying on the river	4
Number of tons of freight carried	2,720
Number of passengers and raftmen carried	11,240
Amount received for carrying freight and passengers	$30,082

W 5.

IMPROVEMENT OF SAINT CROIX RIVER, MINNESOTA AND WISCONSIN.

The work for the improvement of this stream has consisted in the removal of obstructions from the channel, as snags, stumps, old cribs, leaning trees, and the contraction of channels by means of wing-dams, jetties, and closing of secondary channels. Gauge-rods were established and kept up during the year; their readings recorded and plotted.

The work has been done by day labor, and purchase of materials in open market, and was continued throughout the greater part of the winter, the working party moving on the ice.

There have been removed during the year 636 snags, 8 piles, 1 crib, 77 leaning trees, 1 sunken barge, 285 stumps, 17 logs, and 69.5 cubic yards of rock. There were, also, 3,231.5 cubic yards of rock quarried, and gravel excavated and placed in dams, revetment, &c.; 868 cords brush cut and placed in dams, revetment, &c.; and about 1,500 linear feet of dams, revetment, &c., placed, repaired, and leveled up.

Temporary relief was also afforded by scraping bars with railroad-scrapers, worked by horse power through block and tackle on shore.

Last season was noted for heavy floods on all the streams in this section of country. The subsidence of the floods disclosed changes in bed and banks of the stream. A large bar developed above Franconia and for a short time rendered the passage of steamers difficult, but the obstruction was removed by means of temporary dams of brush and stone rapidly constructed; these dams will probably be rendered permanent.

The trade and commerce of the valley have been greatly benefited by the work done to date, and detentions to steamers less common than formerly. It is the common experience of engineers engaged in improving natural channels of rivers that improvement of the stream is almost as certainly followed by overloading of boats and barges beyond what the increase of depth following the improvement would warrant. To illustrate, the ruling depth at low or mean low water may be 3 feet; boats loaded to 3 feet and a few inches struggle over the shallow crossings. The stream is then improved to, say, 4 feet, as much depth as the new regimen will admit of; boats or barges, especially those built for the stream after the improvement has been effected, will then load to, probably, 4 feet and some inches, in which case difficulty will still be experienced at some points and crossings. But the carrying capacity will have been increased. No such detention has as yet followed the improvement of the crossings on the Saint Croix.

Congress, by act approved June 14, 1880, appropriating $10,000 for continuing the improvement, provided that $300, or so much thereof as, in the opinion of the engineer in charge might be necessary, should be expended in the improvement of the slough on the east side of the river, known as the Canal, between Four-Mile Island and the foot of the Saint Croix Boom.

Some rock and other obstructions were removed from this channel.

The present project for improvement, viz, the removal of obstructions from the bed of the stream and the construction of dams, revetment for protection of banks and bends, &c., is based upon report of the survey of 1879, dated January 26, 1880, and published as H. R. Ex. Doc. No. 40, 46th Congress, second session. This report is also printed as Appendix U, Report of the Chief of Engineers for the fiscal year ending June 30, 1880.

The estimated cost of improvement from Taylor's Falls, Minnesota, to Prescott, Wisconsin, was as follows:

11,800 linear feet of dams and jetties	$32,450
2,000 linear feet of shore protection	8,000
Removing snags, stumps, leaning trees, old piers, &c	3,000
Dredging at Willow River Bar, opposite and near to Hudson, Wis	10,800
Dredging at Catfish Bar, about 6 miles below Hudson	6,000
Total	60,250

Congress, by act approved March 3, 1881, appropriated for—

Improving Saint Croix River, below Taylor's Falls, Wisconsin, eight thousand dollars.

With this sum it is proposed to continue the work as begun and in progress.

The total amount appropriated by Congress since the rendition of the report above referred to is $18,000, leaving, as necessary to complete the improvement, $42,250.

The sum of $30,000 can be profitably expended during the fiscal year ending June 30, 1883, in furthering the work between Taylor's Falls and Prescott, and in dredging at Willow River and Catfish Bars.

The work has been in local charge of Capt. O. F. Knapp, overseer, an experienced steamboat and river man who is entitled to credit for zeal and efficiency.

The Saint Croix River is in the collection district of Minnesota. The nearest port of entry is that of Duluth, Minn., at which place the revenue collected during the fiscal year ending June 30, 1881, amounted to $8,351.53.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING SAINT CROIX SIVER, WISCONSIN AND MINNESOTA.

By act approved June 18, 1878*	$10,000 00
By act approved March 3, 1879†	8,000 00
By act approved June 14, 1880‡	10,000 00
By act approved March 3, 1881	8,000 00
Total	36,000 00
Amount (estimated) required for completion of existing project	42,250 00

Money statement.

July 1, 1880, amount available	$10,149 32	
Amount appropriated by act approved March 3, 1881	8,000 00	
		$18,149 32
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	8,057 71	
July 1, 1881, outstanding liabilities	375 89	
		8,433 60
July 1, 1881, amount available		9,715 72
Amount (estimated) required for completion of existing project		42,250 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		30,000 00

* Appropriated before adoption of existing project (see report of Capt. Charles J. Allen, January 26, 1880, printed as H. R. Ex. Doc. No. 40, Forty-sixth Congress, second session.

† Two thousand dollars of this amount was used in making survey of the river from Taylor's Falls to Prescott during 1879.

‡ About $300 of this amount was expended in the improvement of the slough on the east side of the river, known as the Canal, between Four Mile Island and the foot of Saint Croix Boom.

COMMERCIAL STATISTICS, SAINT CROIX RIVER.

FREIGHT AND PASSENGERS.

Owing to the refusal of Capt. J. H. Reaney, manager of one of the steamboat lines on the Saint Croix River, to afford information, the full amount of business for 1880 could not be obtained. Below, however, is a statement of the business for 1879, as furnished by Capt. John H. Reaney, of Saint Paul, Minn., and Capt. David Hays, of Osceola Mills, Wis., under whose direction the boats were operated, which is probably a fair estimate for the season of 1880, to judge from late statements courteously made by Captain Knapp.

There were three steamboats engaged exclusively in the freight and passenger business during the season of 1879, and from the statement it will be seen that the business done was large, when we take into consideration the length of river traversed, less than 60 miles.

Of the three steamboats engaged, two plied between Hastings and Taylor's Falls, and commenced running on the opening of navigation; and the other between Stillwater and Taylor's Falls, and commenced running about August 1.

Commodities.	Number of pounds carried up-stream.	Number of pounds carried down-stream.	Total number of pounds carried.
Flour	7,490,000	810,600	8,300,600
Wheat	17,244,000	8,207,895	25,451,895
Merchandise, &c	9,343,400	2,486,000	11,829,400
Lime	868,800	1,074,300	1,943,100
Bran and feed	87,500		87,500
Barley		60,000	60,000
Oats		24,500	24,500
Salt	90,000		90,000
Total	35,123,700	12,663,295	47,786,995

Passengers carried up and down stream, 9,244.

LUMBER, LOGS, RAFTING, AND TOWING, SEASON OF 1880.

Manufactured.

Lumber	feet..	132,475,078
Shingles	pieces..	54,052,500
Lath	do...	37,845,000

Logs.—About 207,100,000 feet of logs passed through the Saint Croix boom during the season; which, at an estimated value of $9 per thousand feet, would represent the sum of $1,863,900.

Rafting.—This branch of the business requires a large force of men, carried on, however, during only a portion of the season. The amount of lumber and logs rafted foots up about 200,000,000 feet.

Towing.—There were twenty-nine steamboats engaged in the towing of lumber and logs to various points during the season. The amount received for towing foots up about $280,000.

Opening and closing of navigation on the Saint Croix River.

Year.	Opened.	Closed.
1863	April 7	November 20.
1864	April 5	November 12.
1865	April 8	November 20.
1866	April 10	November 25.
1867	April 10	November 24.
1868	March 26	November 25.
1869	April 9	November 13.
1870	April 5	November 21.
1871	March 29	November 22.
1872	April 8	November 20.
1873	April 5	November 25.
1874	April 15	November 15.
1875	April 12	November 15.
1876	April 18	November 25.
1877	April 8	December 31.
1878	April 2	November 20.
1879	April 4	November 17.
1880	April 1	November 13.
1881	April 12	

W 6.

IMPROVEMENT OF MINNESOTA RIVER, MINNESOTA.

No work was done during the fiscal year ending June 30, 1881, there being no funds on hand for such. The project for the improvement of the river from its mouth to South Bend (see report, page 364, Part I, Annual Report of the Chief of Engineers for 1875) contemplated the construction of five locks and dams, and the removal of snags, overhanging trees, and drift piles, at an estimated cost of $733,868.63, which is the existing project.

The spring of 1881 was noted for the sudden rise of the Minnesota River, and great damage to property resulting therefrom. An outline report of this flood, by Mr. J. B. Parkinson, assistant engineer, is appended.

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenue collected during the fiscal year ending June 30, 1881, amounted to $8,351.53.

There are no commercial statistics to report.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MINNESOTA RIVER.

By act approved March 2, 1867	$37,500
By act approved July 11, 1870	10,000
By act approved March 3, 1871	10,000
By act approved June 10, 1872	10,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874 *	10,000
By act approved March 3, 1875	10,000
By act approved August 14, 1876	10,000
By act approved June 18, 1878	10,000
Total	117,500

Amount (estimated) required for completion of existing project (see page 364, Part I, Annual Report of Chief of Engineers for 1875), $733,868.63.

Money statement.

July 1, 1880, amount available		$65 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	$6 00	
July 1, 1881, outstanding liabilities	9 00	
		15 00
July 1, 1881, amount available		50 00
Amount (estimated) required for completion of existing project		733,868 63
Amount that can be profitably expended in fiscal year ending June 30, 1883, for commencement of lock and dam at Little Rapids		75,000 00

REPORT OF MR. JOHN B. PARKINSON, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., June 14, 1881.

SIR: In accordance with your wish communicated to me during the prevalence of the late high-water at Saint Paul, I herewith transmit a brief statement of the appar-

* Used in making survey of river.

ent causes of the flood, together with such comments on the relation of its various phenomena to each other as the limited data at command will permit.

From the large area embraced by the watershed of the Upper Mississippi and the very limited number of meteorological stations established, it seems difficult, on examination of the data available, to establish any very striking relation between the rainfall of any given year and the stage of water in the Mississippi at this point.

This may in part be due to the heavy local showers characteristic of this region, which, by unduly raising the total rainfall at certain points and lowering it at others, might, with only a small number of observing stations, easily produce erroneous premises from which to deduce the flow of water past Saint Paul. By comparing the records taken at Fort Snelling and Saint Paul, 1872 and 1878 inclusive (Report of the Chief of Engineers 1879, pages 1243-1245), it will be seen that a very considerable difference exists even in the records of two stations distant from each other but 7 miles.

In the present instance, however, there would seem to be no difficulty in determining the cause of the flood, viz, the excessive snowfall throughout the entire valley of the Minnesota River during the past winter.

While we have no records taken in that region by which to determine its exact amount, the external evidence is ample that it was greater than had been known for many years.

The record at Saint Paul for the five months November to March inclusive, shows a total of 13.67 inches, as against a mean fall of 5.72 inches for the same months during the past nine years.

When it is remembered that the Minnesota River drains over 16,000 square miles, consisting almost entirely of open prairie, and that a very low temperature prevailed up to the month of April, followed by a great and sudden rise of temperature, some idea can be formed of the immense volume of water suddenly liberated by the advent of warm weather.

At the closing of the Mississippi at Saint Paul, November 16, 1880, the stage of water was 2 feet 2 inches above low-water, and during the severe winter that followed, very little water found its way to the river, so that when the ice finally moved out, April 9, the stage was only 4 feet 6 inches above low-water.

By this date most of the snow in this immediate vicinity had disappeared, but it was not till some ten days later that reports began to arrive of the rising of the streams throughout the Minnesota Valley.

From April 9 to 17 the Mississippi at Saint Paul rose slowly, then more rapidly, to the 25th when it stood at 12 feet, having averaged a little more than 6 inches per day since the 9th.

The Mississippi above the falls was also rising, though quite slowly, and the Minnesota near its headwaters was at a high flood stage.

The most remarkable feature of the flood occurred between the 25th and 26th, when the full effect of the Minnesota rise was first felt at Saint Paul. The record for that day shows a rise of 4 feet in twenty-four hours or more than double any previous rise in the same time at this point during the past nine years.

Most of this rise occurred during the latter half of the twenty-fours, so that during a portion of the time the water came up at the rate of 3 inches per hour.

The following day saw a further rise of 2 feet, the gauge reading 18 feet 2 inches on the evening of the 27th. The culmination of the flood was reached on the night of April 29, the gauge reading 19 feet 8 inches or about 3 inches below the high-water of 1875. The water then began to recede, though much more slowly than it had risen, reaching on May 11, about a 12-foot stage where it remained stationary a few days and then continued its slow decline.

A cross-section of the river taken during the height of the flood showed an area of over 37,000 square feet making the probable discharge at that time at least 175,000 cubic feet per second. A most noticeable feature of this flood was the almost entire absence of rain during its prevalence, the Signal Office at Saint Paul recording but 0.47 inches during April.

This circumstance undoubtedly saved this locality from a flood the consequences of which are hardly to be estimated, as wide-spread rains would have suddenly liberated the deep snows in the forest of the Upper Mississippi to add their volume to the already dangerous flood issuing from the Minnesota.

As gauge-readings have been regularly taken at Saint Paul only since the establishment of the Signal Service Office here in the fall of 1871, it is impossible to go very far back in making comparisons with the floods of former years.

That of 1875 occurred also in April and reached a slightly higher mark. There exists a tradition of the high-water of 1850 which is stated to be 23 feet 10 inches on the present gauge, but investigation has failed to disclose on what authority the statement is made and has also failed to locate the mark.

The accounts given like everything depending entirely on tradition and the "oldest inhabitant" are very conflicting and hence would seem to be hardly worthy of a place

in any record purporting to deal only with well attested facts. Appended will be found a diagram of the gauge-readings at Saint Paul during the months of April and May, 1881.

Very respectfully,

JOHN B. PARKINSON,
Assistant Engineer.

Capt. CHARLES J. ALLEN,
Corps of Engineers, U. S. A.

W 7.

IMPROVEMENT OF RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA.

The work during the year has consisted in dredging and removal of snags and overhanging trees between Moorhead and the head of Goose Rapids. Twenty-six miles were gone over by the dredge during the fiscal year, making a total of 56 miles since the spring of 1879.

A 3-foot depth, low-water channel, has been secured over this entire distance, with least width, through the cuts above the Sheyenne River of 60 feet, and below the Sheyenne of 80 feet. Channel soundings, cross-sections, and comparison of daily gauge-readings over the entire length of stream improved demonstrate the successful nature of the improvement.

It is stated by those in position to know that the transportation of grain by boat and barge last season, following the improvement already made between Fort Abercrombie (75 miles above Fargo) and the point where dredging ceased last year, shows 20 bushels as against one before the work was commenced. Extreme high-water during the latter part of April and the early part of May last precluded commencement of season's operations for a time. The time thus lost for dredging was taken advantage of to make much-needed repairs to the machinery of the dredge, it having worked both day and night during a great part of the season of 1879, thus performing double duty. The fleet also received repairs.

The greatest height of flood attained was on April 30, the gauge showing 24.2 feet above the low-water of 1880 at Moorhead.

The dredge removed during the year 43,561 cubic yards of material; since the commencement of work in 1879, 112,802 cubic yards have been removed; material, a tough, leathery clay, with some sand and bowlders.

In addition, two hundred and forty-four overhanging trees, and ten snags were removed during the past fiscal year. The work was performed by day labor and purchase of materials.

The accompanying report of Mr. Charles Wanzer, assistant engineer in local charge, gives the details of the work done. Mr. Wanzer is entitled to credit for ability and zeal displayed in the management of the work.

The original project for the improvement of the river from Breckinridge to the Boundary Line, as given in the last annual report, based upon the estimate of December 8, 1877 (the cost of lock and dam at Goose Rapids, contained in the estimate of 1877, having been reduced), stated the cost at $335,310.18.

The lock and dam, however, had not been recognized by act of Congress, nor was it ordered until the passage of the river and harbor act, approved March 3, 1881, when it was made the subject of a special appropriation.

Considering, then, the lock and dam as a work for the improvement of the Red River, separate from the work of removing obstructions from the channel, the cost of original project for the removal of obstructions becomes $145,310.18, for which there has been appropriated, to date, by the several acts of Congress, the sum of $103,000, leaving $42,310.18 to be appropriated for carrying on the work, of which sum $25,000 can be profitably expended during the fiscal year ending June 30, 1883, in continuance of dredging between Moorhead and Fargo, and the northern Boundary Line, and of work between the first-named points and Abercrombie above.

Some 40,000 cubic yards of material just above Fargo require removal by dredging.

Congress, by act approved March 3, 1881, appropriated for—

Improving Red River of the North, Minnesota and Dakota, eighteen thousand dollars.

With this sum, and the balance of funds on hand from former appropriations, it is proposed to carry on the work during the coming fiscal year as already begun. An additional dredging machine is in process of construction, to be of somewhat higher performance than the one at present in use, and two tenders or scow-derricks for more rapid disposal of the spoil, with the necessary scows, &c., are now in contemplation.

The Red River of the North is wholly within the customs district of Minnesota, and Pembina the only port of entry, and chief port of the customs district.

The collection of duties and miscellaneous revenues at the port of Pembina and Saint Vincent Station during the fiscal year ending June 30, 1881, amounted to $12,057.06, and the value of exports of American goods at said port and station during said period amounted to $1,450,087.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA.

By act approved August 14, 1876		$10,000 00
By act approved June 18, 1878		30,000 00
By act approved March 3, 1879		25,000 00
By act approved June 14, 1880		20,000 00
By act approved March 3, 1881		18,000 00
		103,000 00
Original estimate for completing existing project, not including lock and dam, at Goose Rapids		$145,310 18
Remaining to be appropriated		42,310 18

Money statement.

July 1, 1880, amount available	$46,146 42	
Amount appropriated by act approved March 3, 1881	18,000 00	
		$64,146 42
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	9,047 62	
July 1, 1881, outstanding liabilities	798 98	
		9,846 60
July 1, 1881, amount available		54,299 82
Amount (estimated) required for the completion of existing project		42,310 18
Amount that can be profitably expended in fiscal year ending June 30, 1883		25,000 00

REPORT OF MR. CHARLES WANZER, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., June 30, 1881.

MAJOR: The work on the Red River of the North for the year ending June 30, 1881, has consisted of dredging, the removal of snags and overhanging trees, and an exami-

nation of the river from Breckenridge to Fargo, which latter has been already reported upon.

The work of dredging has been carried on by hired labor, and by the dredge built by the United States in the spring of 1879.

Twenty-six miles of river have been gone over by the dredge during the fiscal year, and a total of 56 miles has been dredged over since the spring of 1879. The dredge is now working at a point 5 miles by river above the mouth of the Elm, and commenced this season where it ended last fall.

A 3-foot low-water channel has been provided over this entire distance.

Accurate gauge readings have been continually kept on the work and checked up frequently with the permanent gauges set at Moorhead and at the mouth of the Elm River, and these records afford ample evidence that no injury has been done by too much excavation, an excess of which would easily drain the river above the work. (A table of slopes and distances on the river is herewith submitted, covering the entire distance from Breckinridge to Pembina.)

For that portion of the river above the mouth of the Sheyenne, a 60-foot navigable width of channel was provided, while below the junction of the two rivers a width of 80 feet has been furnished.

An examination was made during the month of last September to ascertain the effects of the spring and summer freshets of last season.

Channel-soundings were taken from Moorhead to the dredge, and this examination demonstrated that the channel excavated prior to the taking of the soundings had fully maintained its original depth as made by the dredge, and in fact had been somewhat improved by the action of the current wearing off the uneven ridges left by the dredge.

The training and wing-dams, which have been built of the excavated material, had withstood the action of the river, as well as could be expected, and where "washing" had taken place, it had only lowered somewhat the crest of the dams, and deposited the earth further into the bends.

Operations closed on the river for the season of 1880 on October 23, and the dredge and outfit were laid up for the winter at Moorhead, Minn.

This spring, one of the barges was newly decked and recalked, and the machinery and boiler were repaired, particularly the flues of the boiler were taken out, welded and reset, and new key seats were cut in all gearing and shafting, and the dredge started at work this spring in as good apparent condition as when new. Operations did not recommence this spring until May 27, being twenty-four days later than last year. This delay was owing to the extreme high-water experienced during the latter part of April and the first part of May. The greatest height the flood attained was 24.2 feet above the low-water of 1880 at Moorhead.

The dredge worked during the season of 1879 ten hours per day, with the exception of the months of September and October, when it was operated both night and day.

During the season of 1880 and up to date of this year it has been worked eleven hours per day, and has moved during the last fiscal year 43,561 cubic yards; since first commencing operations 112,802 cubic yards; and has in every respect given good satisfaction.

No detailed or specific examination has yet been made of the effect of this spring's high-water on the work, but as far as observed no injury has been done, and as soon as the river recedes to a lower stage a thorough examination will be made.

The work of removing snags and overhanging trees was done during the month of September, 1880, by the dredging crew, and was undertaken at a time when the dredge was necessarily idle, awaiting repairs to its machinery. The portion of the river improved by this snagging party was from Moorhead to the mouth of the Sheyenne River.

The number of overhanging trees removed was 244. The number of snags removed, 10.

In conclusion, I would respectfully refer to the exceeding high-water of this spring on this river as a subject naturally leading to the question of the examination of the sources of the stream, in reference to the feasibility of constructing reservoirs similar to those proposed on the Upper Mississippi River.

The river above Fergus Falls could at least be examined at a small expense, and undoubtedly advantageous sites could be selected for impounding the surplus spring supplies.

The Red River of the North is so narrow over its entire length, with well defined banks, that an increment of 1,000 cubic feet per second to the ordinary low-water discharge would furnish a good navigable stage at all times from Fort Abercrombie to the head of Goose Rapids, while an increment of 2,000 cubic feet per second would, with the aid of some removal of rocks and bowlders, render navigation over Goose Rapids perfectly safe.

Conjecture, in the absence of positive knowledge of the country, is futile, but I believe a wise economy would dictate that such an examination as proposed should be made.

Table of slopes and distances by river, from Breckinridge to Pembina.

From Breckenridge to station.	Fall between stations.	Total fall.	Distances between stations.	Total distance from Breckinridge.	Slope per mile between stations.
	Feet.	*Feet.*	*Miles.*	*Miles.*	*Feet.*
Woodson	2.421	2.421	2.42	2.42	1.00
Island No. 5	2.790	5.211	2.57	4.99	1.08
Head Connolly's Rapids	4.652	9.864	3.93	8.92	1.18
Foot Connolly's Rapids	3.727	13.591	1.30	10.22	2.86
Beanmers	8.537	22.128	5.68	15.90	1.50
First United States Reservation Post	4.588	26.716	3.25	19.15	1.41
Fort Abercrombie	8.826	35.542	6.82	25.97	1.29
Second United States Reservation Post	6.119	41.661	6.60	32.57	0.927
Uhlan's Bend	6.829	48.490	9.60	42.17	0.71
Ole Hicks	16.313	64.803	27.10	69.27	0.602
Mouth Rice River	5.863	70.666	13.20	82.47	0.444
Fargo	5.733	76.399	19.10	101.57	0.300
Elm River	31.589	107.988	61.52	163.09	0.513
Goose River	14.971	122.959	28.63	191.72	0.523
O² Goose Rapids	1.422	124.381	1.00	192.72	1.422
P² Goose Rapids	1.444	125.825	1.82	194.54	0.793
R² Goose Rapids	1.226	127.051	1.94	196.48	0.632
W² Goose Rapids	4.563	131.614	2.12	198.60	2.152
X² Goose Rapids	1.246	132.860	1.74	200.34	0.716
Z² Goose Rapids	0.660	133.520	1.06	201.40	0.622
A³ Goose Rapids	0.683	134.203	1.82	203.22	0.375
Proposed dam	0.550	134.753	1.14	204.36	0.482
D³	3.308	138.061	4.55	208.91	0.727
Frog Point	10.165	148.226	9.30	218.21	1.093
Grand Forks	12.800	161.026	35.00	253.21	0.365
Turtle River	6.200	167.226	25.00	278.21	0.403
Pelican Bar	20.661	187.887	70.50	348.71	0.293
Pembina	9.333	197.220	48.00	396.71	0.194

Very respectfully, your obedient servant,

CHARLES WANZER,
Assistant Engineer.

Commercial Statistics Red River of the North, between Abercrombie, Dakota Territory, and Boundary Line, during season of 1880.

Carried by—	Pounds carried down stream.	Pounds carried up stream.	Character.
Alsop Line of steamers	5,993,181	3,997,000	Wheat, merchandise, wood.
Flat boats and rafts	9,833,345	.....	Wood, lumber, merchandise.
Barges	1,170,320	.....	Wheat.
Grandin Line of steamers	4,590,284	10,568,995	Wheat, merchandise.
Red River Transportation Co	7,040,390	102,000	Merchandise.
Total	28,633,520	14,667,995	

Total pounds up and down stream, 43,301,515, of which amount 15,620,215 pounds was wheat.

The Red River was open and free from ice for a period of two hundred and fourteen days.

There were eight steamboats, twenty-two barges, and a large number of flat-boats engaged in the carrying trade.

The flat boat on this river is a temporary arrangement for running down stream only (put together of merchantable lumber), which, having been utilized for freight purposes, is knocked to pieces when it arrives at destination, and sold for lumber.

The principal interest in the Red River Valley is wheat raising and general farming.

Railroads cross the river at Breckinridge, Moorhead, and Grand Forks.

With a lock and dam at Goose Rapids it is estimated that 1,000,000 bushels (minimum) of wheat, alone, would annually find its way to market by river to the railroad crossings.

By reference to the statement above, it will be seen that the amount shipped from Abercrombie to Fargo (between which points the only improvement of the river has

been that of removing some snags and bowlders, and cutting down leaning trees), in 1880, foots up 1,529,220 pounds wheat and 7,200,000 wood; total, 8,729,220 pounds, which, considering the scant shipping facilities, is not regarded as small and represents but a portion of the business that may be expected when the river is cleared of snags and other obstructions sufficiently to warrant the risk of placing additional steam boats and barges upon it. Yet, it is stated upon good authority, that a line of boats will be put on the river this season between these places to carry wheat, &c., to the railroads.

Over 250,000 bushels of wheat are directly tributary to the river between the points named.

RED RIVER VALLEY—ITS EXTENT.

The extent of the region known as the Red River Valley is about 225 miles east and west by 300 miles north and south. It contains, approximately, 67,500 square miles, or 259,200,000 acres of land, over 80 per cent. of which acreage comprises the finest farming land for the production of cereals and stock raising in the world. Wheat, corn, oats, rye, barley, and flax are raised in abundant quantities, and with less labor than in the older States and Territories.

W 8.

CONSTRUCTION OF LOCK AND DAM AT GOOSE RAPIDS, ON THE RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA.

An estimate, under date of December 8, 1877, of the cost of improving the Red River of the North from Breckenridge to the Boundary Line, contained as item the cost of lock and dam at Goose Rapids, $219,287.99. Preceding and successive reports have stated the necessity of such a structure to overcome the accumulation of fall of water surface over the reach of shoals, bowlder deposits, &c., known as Goose Rapids. The accompanying estimates have varied, keeping pace with prices of material and other developments, as well as with the seeming change in necessity of navigation. The first estimate was made at a time when the Red River was less accessible by railroad than at present, and when the cost of labor and material was involved in some uncertainty.

Transportation of grain by steamer and barge has increased below Moorhead twenty-fold since the United States dredge was launched and put in operation early in 1879.

The lock and dam proposed are to provide for lift of about 12 feet.

The estimated cost of lock and dam of the dimensions proposed, $200,000. The lock to be located, probably, between Island No. — and left bank at a point about 12½ miles below the Goose River, which enters by the left bank. It is estimated that the lift will pond back the low-water surface 12½ miles, affording within this reach 4 feet least depth for navigation. Some dredging will be necessary below the lock, which is provided for in the estimates pertaining to the Red River improvement from Breckenridge to the Boundary Line.

Congress by act approved March 3, 1881, made the first appropriation for the work as follows:

> Constructing a lock and dam at Goose Rapids, on the Red River of the North, Minnesota and Dakota, twenty thousand dollars.

This sum, being but 10 per cent. of the estimated cost of the structure, is regarded as inadequate for the commencement of work, especially so during the present high price of materials. If prices lower materially during the present year, expenditure of the present appropriation for material, so far as it will go, might be considered.

On account of the complications and claims that would arise from the construction by the United States Government of reservoirs upon the Rock River, it would seem best to leave such to private parties or corporations.

Assistant Frizell's report of November 8 is so full of interesting facts that I forward it entire.

I will add that the rendition of this report has been delayed thus far, as I had intended it to form part of the report of the season's work appertaining to the reservoir system.

A tracing of the area under consideration, scaled 1 inch to 10 miles, is also inclosed.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JOSEPH P. FRIZELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY.
Saint Paul, Minn., November 8, 1880.

SIR: The act of Congress approved June 14, 1880, calls for an examination or survey of Rock River, in Wisconsin and Illinois, with reference to the construction of reservoirs thereon. I visited the river, by your orders, in September last, and examined the principle localities suitable for reservoirs. I have also gained what information I could concerning the subject from other sources, and have the honor to present the following preliminary report, embodying considerations proper to be taken account of before incurring the expense of a survey.

At the head of the river, in Dodge and Fond du Lac counties, is a vast marsh capable of being flooded by a dam at the village of Horicon, in the town of Hubbard. A dam was constructed at this point in 1842, which flowed, it is said, some 60 square miles of ground, raising the water 9½ feet at the dam. This dam stood till 1868, furnishing power to mills at Horicon, around which a considerable village grew up. In 1868 the dam was removed by order of the court, judgments having been obtained against its owners, the Merchants' Union Manufacturing Company, by land-owners, which the former were unable to pay.

The drainage ground appurtenant to the Horicon reservoir is about 491 square miles. There is an exceedingly favorable site for a dam, which need not be more than 200 feet long to raise the water 10 feet. There is nothing to prevent raising the water higher than 10 feet. The cost of the dam would be comparatively slight, but the expense of land damages would be heavy, amounting probably to $200,000 or $300,000. We can estimate the capacity of a reservoir required here to reduce the discharge of the drainage ground. By the records of the United States Signal Service kept at Milwaukee, the total rainfall of the eight years, 1872–1879, inclusive, was 282.63 inches, being 35.33 inches per annum. We may assume that 40 per cent. of this finds its way into the reservoir, giving per annum 16,120,000,000 of cubic feet. Assume evaporation in reservoir ¼ inch per day for seven months, there must be deducted $7 \times 30 \times \frac{1}{48} \times 60 \times (5280)^2$, equal to 7,318,000,000 of cubic feet; giving for the annual product of the drainage ground 8,802,000,000 of cubic feet.

In the parliamentary inquiry relative to the East London Water-works, it was stated by eminent English engineers, as a result of extensive observation, that a reservoir, to reduce the flow of its drainage ground to uniformity, should be capable of holding about eighteen months' average flow. The greatest desirable capacity of this reservoir, therefore, is 1½ times $8,802,000,000=13,203,000,000 of cubic feet. This would require the water to be raised about 16 feet, giving an average depth of 8 feet over the whole flowage ground.

The Merchants' Union Manufacturing Company still own the greater part of the marsh-land that would be flowed. It is assumed that this company would release the land to the United States in consideration of the water-power to be created by the dam.

Beaver Dam Lake, in Dodge County, covers about 6,000 acres.

It is wholly created by a dam at the village of Beaver Dam, which raises the water 6 feet. I judge that the quantity of water would warrant the raising of the dam

somewhat higher, but not much. This region abounds in extensive marshes, and it is quite probable that a careful examination would disclose many localities adapted for the storage of large quantities of water.

Lake Koshkonong, lying mainly in Jefferson County, is an enlargement of Rock River, covering 25 or 30 square miles, and commanding a drainage ground of 2,542 square miles, or 2,051 square miles excluding the Horicon watershed. It is already controlled to a slight extent as a reservoir by a dam at Indian Ford, owned by the Janesville manufacturers. No physical obstacle exists to the construction of a dam 20 feet high, but it would involve very heavy damages, greatly extending the area of the lake, and flowing out mill privileges above. It is not probable that a reservoir could be constructed here large enough to meet the requirements of the drainage ground. The total product on the above basis would be, excluding Horicon, something like 40,000,000,000 of cubic feet per annum, calling for a storage capacity of 60,000,000,000. A 20-foot dam would not probably furnish over 20,000,000,000, leaving the balance to be sought in some other part of the valley.

Lakes Mendota and Menona cover some 25 square miles, and command a large drainage ground, but their situations, encircling as they do the city of Madison, probably forbid their use as reservoirs to any great extent. Judging from the general character of the country and the frequent occurrence of extended marshes, I see no reason to doubt the physical practicability of impounding the waters of Rock River above Janesville as far as may be desired, though at a very heavy expense, especially for the item of land damages.

It is worth while to consider, however, whether such an improvement would be of material benefit to the Mississippi River. General J. H. Wilson's assistants found 47,000 cubic feet per second as the ordinary low-water volume of the Mississippi at Rock Island. Mr. T. C. Clark found about the same quantity for the low-water volume at Quincy. General G. K. Warren found 36,100 cubic feet per second at Burlington in 1866, when the river was 1 foot above extreme low-water, indicating about 32,000 at the latter stage. General Wilson found the discharge at Keokuk at ordinary low-water 40,435 cubic feet per second. Assume, for purpose of discussion, that the above supposed system of reservoirs could discharge 50,000,000,000 of cubic feet per annum. Could this volume be concentrated into the ordinary period of low-water, say 100 days, it would furnish for that period 5,787 cubic feet per second. This would be a considerable fraction of the volume of the river, and would have an appreciable effect upon the stage of water. It would cause a rise of about 6 inches on the Des Moines Rapids at ordinary low-water. The extensive use of the Rock River for water-power, however, would prevent any such use of the reservoirs. Dams are constructed across the river and important industries established at many points on the stream, notably at Hustisford, Watertown, Jefferson, Indian Ford, Janesville, Beloit, Rockton, Rockford, Dixon, Sterling, and Rock Island. That these industries are destined to immense development in the near future, we are admonished by the growth of manufacturing towns in the Eastern States, where I observed, a few weeks ago, the strange spectacle of a manufacturing establishment, originally built to be driven by water-power, having attained such dimensions that the low-water volume of the stream was not sufficient to feed its boilers and wash its goods. Any extended interference by the government with the natural flow of waters on this stream would lead to endless reclamations on the part of mill-owners. These industries have been established in the full faith that the usual course of nature will be maintained on this stream, and any interference therewith, to the detriment of the mills, would lead to claims for compensation. The interests of navigation on the Mississippi would dictate holding back all the water during the winter and spring, and discharging it in great volumes in the latter part of the summer and autumn. This would be directly opposed to the interests of manufacturers. A sort of compromise on this point would consist in discharging from the reservoirs, at all times, a quantity equal to the low-water volume of the stream, but what that low-water volume is could never be determined to the satisfaction of all parties. The difficulty would increase as the manufactures extended. When an industry dependent on water-power attains such dimensions that it is liable to frequent interruptions from lack of water, the ordinary proceeding is to introduce a steam-engine to be run during periods of low-water, depending wholly upon water-power at other times. This enables the establishment to profitably use a much larger portion of the high-water volume, and restricts correspondingly the quantity of water that can be held by reservoirs. Even leaving the legal rights of the manufacturers out of consideration, it requires little argument to convince those familiar with the usual course of public affairs that reservoirs constructed on the headwaters of the Rock River would be operated in accordance with the interests of manufacturing on that river, rather than those of navigation on the Mississippi. These two interests would be identical in certain conceivable circumstances, but under any circumstances likely to arise they would be different. Were there but one reservoir, say that at Horicon, the interests of manufacturing would require that it should be used to keep up the low-water volume of the Rock River, and this use would coincide with the require-

ments of navigation on the Mississippi, provided low-water occurred at the same time on both. It must be observed, however, that the Horicon reservoir alone would be of no appreciable benefit to the Mississippi. The above is an extreme supposition. Let us now go to the other extreme, and suppose the system of reservoirs to be sufficiently extended to impound all the water of the Rock River for a period of eighteen months, the manufactures being also supposed to have extended sufficiently to use all the water that can be obtained. Then it is plain that manufactures would require the water to be discharged at a uniform rate during the entire year, a method that would be of little use to the Mississippi, which would still demand the concentration of the discharge into the period of low-water.

There is still another case conceivable in which both interests would be identical. Imagine reservoirs to be applied to all the affluents of the Mississippi of capacity sufficient to hold the total flow for eighteen months. This would be the culmination of the reservoir system, reducing the flow of the river and all its tributaries to uniformity at all seasons. In that case a uniform discharge from all the reservoirs would exactly meet the requirements both of manufacturing and navigation. Such a system applied throughout the entire Mississippi Valley would cost not less than $1,000,000,000, and, of course, the event of its adoption is too remote to be seriously considered.

We may, however, as it appears to me, rest assured that the question of reservoirs on the Rock River will take care of itself. The manufacturing industries have already attained dimensions that require the aid of reservoirs, Lake Koshkonong, as already stated, being controlled to some extent in that interest. The necessity for these accessions will become more and more apparent as these industries expand. In the course of twenty years we shall probably see the resources of this stream taxed to their utmost with all the aid that can be derived from reservoirs. The owners of water-power on the Merrimac River, in New Hampshire and Massachusetts, control reservoirs to the extent of 200 square miles of water surface. Yet the steam-power now in use in Lowell exceeds the water-power in amount. A committee of the Massachusetts legislature, some six years ago, reported that there were then over three hundred storage reservoirs in that State operated in the interest of manufacturers. To show what motives will exist for the construction of reservoirs on Rock River, let us compute the value of the Horicon reservoir, on the assumption that there is use for the increase of power derived from it. When the Horicon dam was in existence, the total fall from the surface of the Horicon reservoir to the Mississippi at Rock Island was 333 feet. (See Survey of Rock River, H. Ex. Doc. No. 15, Fortieth Congress, first session.) Of this fall we must reject about 75 feet as in operation, for the reason that the discharge of the reservoir, under most judicious management, will not be of full benefit to the river till it reaches a point where the latter has a considerable volume independent of the reservoir. From the remaining 258 feet we must reject that part of the fall employed in giving movement to the water. I found on the Charles River, in Massachusetts, that the aggregate fall at the several dams was about eight-ninths of the total fall. A similar proportion here would give 229 feet. In addition, allow 1 foot in 20 for losses in penstocks and raceways, and we have, for the total available fall, 218 feet.

We have seen that the Horicon watershed could furnish per annum, by impounding all the water, 8,802,000,000 of cubic feet; out of this there must be deducted the low-water flow, roughly estimated at 50 cubic feet per second, amounting to 1,578,000,000 of cubic feet. Balance available for increase of water-power, 6,224,000,000 of cubic feet. This would furnish during the period of low-water, assumed to last 120 days, 600 cubic feet per second, flowing continuously. The numerous dams on the stream, however, would to a large extent give the means of concentrating the discharge during low-water into the working hours of the day. Fully accomplished, this would increase the discharge to over 1,200 cubic feet per second. Practically, it would not, probably, amount to over 900. The effect of the reservoir, therefore, is to add 900 cubic feet per second to the available volume of the river. It enables the mills to increase their draught for that amount without fear of interruption from low-water. For ordinary purposes it is sufficiently accurate to say that 1 cubic foot of water per second on 12 feet fall (or 12 cubic feet per second on 1 foot fall) is an effective horse-power, that is, a horse-power available for driving machinery. The effect of the reservoir therefore is to add $\frac{900 \times 218}{12}$ equal to 16,350 horse-powers to the manufacturing capacity of the stream. Water for power is leased at Minneapolis at the rate of $20 per annum per horse-power. At this rate the improvement would be worth $327,000 per annum.

The question may be approached in a more direct and simple manner. I am informed by Mr. S. Clark, who was one of the owners of the Horicon reservoir, that the cash value of the water discharged by it, on an average fall of less than 8 feet, was $15,000 per annum. The water would have an equal value, did manufacturing require it, on each and every 8 feet of fall on the stream. The total effective fall of the entire stream from Horicon to Rock Island, estimated as above, is 280 feet, giving for the

total value of the reservoir $525,000. This does not take account of the fact that the low-water volume cannot be impounded. That fact considered would reduce the value to some $400,000 per annum. Without attaching undue importance to these figures, they make it apparent that the construction of reservoirs on Rock River will in a few years be a profitable investment for private capital, and we may safely conclude that the government is under no necessity of undertaking works for whose construction by private enterprise such strong inducements are likely to arise. This stream presents in a stronger light than any hitherto considered the relation of reservoirs to water-power, and foreshadows in some degree the complications likely to spring from that relation in the application of the reservoir system. I have thought it advisable, on that account, to consider the matter more in detail than would otherwise appear necessary.

Very respectfully, your obedient servant,

JOS. P. FRIZELL,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

ZEROS OF GAUGES 1873 TO 1880 REFERRED TO THE LEVEL OF THE SEA.

Mississippi above Saint Paul.

	Elevation in feet.
Gauge at Leech Lake:	
1874. Zero	1,293.086
1878. Zero	1,292.561
Gauge at Tidd's Camp:	
1878. Zero	1,270.525
Gauge at Grand Rapids:	
1874. Zero	1,248.807
1878. Zero	1,248.707
Gauge at Sandy Lake:	
1874. Zero	1,208.610
Gauge at Aiken:	
1874. Zero	1,190.263
1879. Zero	1,186.415
1880. Zero	1,187.989
Gauge at Pokegama Lake:	
1874. Zero	1,269.410
Gauge at Brainerd:	
1874. Pump-house gauge, zero	1,147.038
1875. Zero	1,153.009
1879. Zero	1,150.041
1880. Zero	1,150.041
Gauge at Crow Wing:	
1874. Zero	1,147.023
Gauge at Sauk Rapids:	
1875. Upper gauge, April 17, zero	989.924
1875. Lower gauge, April 17, zero	988.566
1875. Upper gauge, May 11, zero	987.919
1875. Lower gauge, May 11, zero	988.511
1879. Zero	989.251
Gauge at Fridley's Bar:	
1875. Upper gauge, April 26, zero	801.031

Red River of the North.

Gauge at Breckinridge:	
1874. Zero	941.030
Gauge at Fort Abercrombie:	
1874. Zero	909.990
Gauge at Fargo:	
1873. Zero	866.480
1874. Zero	867.705
1877. Zero	866.480
1879. Zero	865.529
1880. Zero	868.530
Gauge at Elm River:	
1879. Zero	832.996
1880. Zero	832.996

	Elevation in feet.
Gauge at Caledonia:	
1873. Zero	820.160
1879. Zero	820.160
1880. Zero	820.160
Gauge at Frog Point:	
1873. Zero	795.809
1877. Zero	800.100
1879. Zero	795.800
1880. Zero	797.700
Gauge at Grand Forks:	
1879. Zero	784.899
Gauge at Pembina:	
1877. Zero	752.153

Chippewa River.

Gauge at Eau Claire:	
1878. Zero	750.688
1880. Zero	750.688
Gauge at Flambeau Crossing, Muscalonge Falls:	
1879. Zero	1,444.600
Gauge at Rest Lake, at dam-site No. 1:	
1878. Zero	1,571.577
Gauge at mouth of Rest Lake, No. 2:	
1878. Zero	1,571.594
Gauge at head of Rest Lake, No. 5:	
1878. Zero	1,571.571
Gauge at mouth of Little Manitouish Lake, No. 6:	
1878. Zero	1,574.620

Saint Croix River.

Gauge at Pine City Crossing:	
1880. Zero	795.236
Gauge at Chengwatana, Snake River, tributary to Saint Croix:	
1880. Zero	929.674
Gauge at Taylor's Falls:	
1880. Zero	684.160
Gauge at Stillwater:	
1879. Zero	666.952

Superior Bay.

Gauge at Duluth:	
1873. Tide gauge, Minnesota Pier, zero	602.901
1873. Tide gauge, end of pier Rice's Point, zero	604.641
1873. Tide gauge, north pier of canal, zero	603.607
1879. Board gauge, near inner end of canal, zero	586.112
Gauge at Saint Paul:	
Zero	682.536

NOTE.—The zeroes of all the above gauges are referred to the Saint Paul gauge, with the above elevation. The bench marks and corresponding descriptions are on file in the United States Engineer Office, Saint Paul, as well as particular description of locality of each gauge-rod.

TABLE OF ELEVATIONS OF IMPORTANT POINTS IN EASTERN DAKOTA, IN MINNESOTA, AND IN WISCONSIN, ABOVE SEA-LEVEL, THE SURFACE OF LAKE SUPERIOR AT DULUTH TAKEN AT 602 FEET ABOVE SEA-LEVEL.

Mississippi River above Saint Paul.

	Feet.
Bench mark, water table, northeast corner of brick building opposite Metropolitan Hotel, Saint Paul, Minn., occupied as United States river and harbor office	785.200
0 of gauge on main pier of Saint Paul bridge	682.526
0 of Signal Service gauge, lower town level Saint Paul	682.536
Low-water in Mississippi River at Saint Paul, 1864	683.036
High-water in Mississippi River at Saint Paul, 1881	702.036
Bench mark on east corner of coping, down stream, wing-wall of abutment, north end of Saint Paul and Sioux City Railroad bridge	702.439

	Feet.
Water surface at Fort Snelling bridge, November 3, 1879	690.163
High-water at Fort Snelling bridge, July, 1879	697.933
Bench mark on bowlder, upper end of Bridal Veil bridge, on river side	804.654
0 of gauge on railroad bridge at Saint Anthony Falls	790.614
Bench mark on inner edge of door-sill, east end of City Hall building, Minneapolis, Minn	838.553
Water surface, lower end of Hennepin Island, October 8, 1874	739.168
Water surface below Saint Anthony Falls, opposite lower end of old stone mill, on west side of river, October 5, 1874	752.989
Water surface, 40 feet above the falls of Saint Anthony, October 5, 1874	782.079
Bench mark on water table, southwest corner of flour mill, opposite falls on Marshall street, Minneapolis	812.051
Water surface, Mississippi River, at mouth of Rice Creek, October 1, 1874	804.665
Bench mark on burr oak, 12 inches in diameter, at mouth of Rice Creek	815.763
Water surface, Mississippi River, at Anoka Ferry, September 28, 1874	829.488
Bench mark, burr oak tree, 100 feet below Anoka Ferry	835.961
Water surface, Mississippi River, at Dayton, September 22, 1874	843.823
Bench mark on alder, 50 feet from river at Dayton Ferry	852.871
Water surface, Mississippi River, at Monticello, September 10, 1874	898.577
Bench mark on burr oak, 10 inches in diameter, at Upper Ferry, Monticello	902.164
Water surface Mississippi River, at head of Bear Island, September 5, 1874	924.602
Bench mark on elm, 20 inches in diameter, at head of Bear Isiand	929.365
Water surface, Mississippi River, at Clear Water, September 1, 1874	938.033
Water surface at Railroad Bridge, Saint Cloud, August 21, 1874	969.159
Water surface at Sauk Rapids, opposite the mouth of Sauk River, November 12, 1874	992.014
Bench mark on stone with copper bolt, opposite the mouth of Sauk River	1,004.620
Water surface on the Mississippi River, at foot of breakwater, Sauk Rapids, August 10, 1874	984.660
Water surface at head of Watab Rapids, November 10, 1874	1,003.225
Bench mark on large burr oak, in front of J. Campbell's house at Watab, between school-house and old mill	1,018.526
Water surface in the Mississippi River, at Watab, November 7, 1874	1,004.393
Elevation of surface of ground at Watab	1,021.733
Water surface in the Mississippi River, at the mouth of Little Rock River, November 7, 1874	1,003.464
Water surface in Little Rock River, at stage-road ford, November 7, 1874	1,009.496
Elevation of grade at Brainerd Branch of the North Pacific Railroad, at Little Rock River	1,056.286
Water surface in Plat River, at Langola, November 4, 1874	1,038.701
Water surface at upper end of island, at McDougal's Rapids, November 1, 1874	1,036.599
Water surface at head of Pike Rapids, October 28, 1874	1,070.172
Water surface at foot of Pike Rapids, October 28, 1874	1,067.194
Bench mark at head of Pike Rapids, pine tree at head of rapids	1,103.247
Water surface at ferry head of rapids, at Little Falls, October 20, 1874	1,093.330
Water surface at foot of Little Falls, opposite Mill Island, October 24, 1874	1,086.231
Bench mark on jack oak, in front of Lafond's store, at Little Falls	1,116.907
Water surface at head of Little Elm Rapids, October 20, 1874	1,105.174
Water surface in the Mississippi River at head of Conradis Shoals, October 16, 1874	1,108.981
Water surface at foot of Conradis Shoals	1,106.804
Water surface at mouth of Nokaysippi River, October 9, 1874	1,142.188
Bench mark, elm tree, between ferry at Fort Ripley and mouth of Nokaysippi River	1,114.313
Water surface in the Mississippi River, at the mouth of the Crow Wing River	1,150.436
Low-water at Crow Wing, October 28, 1874	1,148.423
Water surface in Mississippi at the head of Island Rapids, September 8, 1874	1,167.705
Water surface at foot of Island Rapids	1,167.375
Water surface at head of Big Eddy Rapids, September 7, 1874	1,173.349
Water surface at foot of Big Eddy Rapids	1,170.801
Bench mark on pine tree at head of Big Eddy Rapids	1,210.702
Elevation of water surface, Mississippi River at the mouth of Pine River, August 25, 1874	1,180.327
Elevation of track-stringer, east end of old North Pacific Railroad bridge, at Brainerd	1,213.901
Bench mark at Brainerd pump-house, on pine 2½ feet in diameter	1,171.246

	Feet.
Elevation of top of tile on North Pacific Railroad at east end of depot at Aitken, Minnesota	1,211.353
Bench mark on large elm on right bank of Mississippi River, at Aitken, Ferry	1,203.413
Low-water in Mississippi River at Sandy Lake, 1874	1,212.210
Low-water in Mississippi River at Sandy Lake, 1879	1,210.146
Water surface at Sandy Lake, Mississippi River	1,210.848
Bench mark on elm, 20 inches in diameter, left bank of Mississippi River, 100 feet below the mouth of Sandy Lake River	1,221.726
Water surface in Mississippi River at mouth of Split-hand River, October 16, 1874	1,235.952
Water surface, Split-hand River, 2 miles from mouth, October 16, 1874	1,253.298
Water surface of the Mississippi River at head of Grand Rapids, October 14, 1874	1,253.168
Water surface at foot of Grand Rapids, October 14, 1874	1,248.042
Bench mark on stump at Grand Rapids, half way from steamboat landing to hotel, 30 feet from bank of river	1,254.640
Water surface in Mississippi at head of Pokegama Falls, October 11, 1874	1,269.867
Water surface at foot of Pokegama Falls, October 11, 1874	1,255.700
Bench mark at Pokegama Falls, arrow on stone with letters U. S. B. M., 75 feet below main fall, 20 feet from river bank	1,279.933
Guard bench mark, arrow on bowlder, 3 feet north of first bench mark	1,279.803
Water surface, Mississippi River, above Pokegama Falls, October 15, 1880	1,269.088
Water surface, Mississippi River, below Pokegama Falls, October 15, 1880	1,254.230
Water surface in Pokegama Lake, October 19, 1880	1,271.293
Bench mark 3 feet in diameter at end of trail, east bank of Pokegama Lake	1,280.397
Water surface, Little Bass Lake, October 19, 1880	1,283.401
Bench mark on fir 10 inches in diameter, 400 feet northwest of the southwest corner of Little Bass Lake, on logging road	1,293.210
Water surface in Bass Lake, October 19, 1880	1,279.276
Bench mark on Bass Lake, white birch on southeast arm, 30 feet from east shore, 500 feet southeast from thoroughfare connecting arm with main lake	1,284.676
Water surface in Shoal Lake, October 19, 1880	1,295.927
Bench mark on white pine stump 2 feet in diameter, 10 feet from shore on south side of Shoal Lake, one-fourth mile southeast of the west end	1,300.746
Water surface in Hale's Lake, October 29, 1880	1,272.526
Bench mark on poplar 9 inches in diameter, at head of Hale's Lake	1,287.784
Water surface in the lake at head of Split-hand Creek, sections 29, 30, 32, township 54, range 25, 1880	1,307.622
Water surface in Rice's Lake, section 28, township 55, range 26, October, 1880	1,277.911
Bench mark on bass-wood 18 inches in diameter, 6 feet east of Pokegama Lake, trail near northeast corner of lake	1,300.991
Elevation of water in Lake No. 1, on Pokegama Brook, October, 1880	1,271.037
Water surface, Lake No. 2, on Pokegama Brook, October, 1880	1,275.881
Bench mark on cedar 2 feet in diameter, on bank of Lake No. 2, 100 feet south of old camp	1,280.687
Water surface at Tidd's Camp, October 5, 1874	1,273.718
Bench mark on stump, 30 feet from inner bank, at Tidd's Camp	1,276.491
Elevation of water in Two-Route Lake, on White Oak Portage, September, 28, 1874	1,277.441
Bench mark on Norway pine, on trail from Two-Route Lake to the Mississippi River	1,289.227
Height of land on White Oak Portage	1,300.485
Water surface in the Mississippi River, at the mouth of Vermillion River, October 30, 1878	1,272.624
Bench mark on Norway pine 2 feet in diameter, about 1,000 feet below the mouth of Vermillion	1,294.150
Water surface in the Mississippi River, at the mouth of Vermillion River, November 8, 1880	1,273.856
Water surface of Vermillion Lake, November 8, 1880	1,277.925
Bench mark on balsam on toll-road, bank of Vermillion Lake	1,289.078
Water surface, Mississippi River, at White Oak Point, September 28, 1874	1,278.630
Water surface at junction of Mississippi and Leech Lake rivers, September 28, 1874	1,282.084
Bench mark on Leech Lake River, first point of land on left bank above the junction of the Mississippi and Leech Lake rivers, oak tree 8 inches in diameter	1,285.572
Water surface in Ball Club Lake, September 7, 1874	1,280.958
Water surface in Little Winnibigoshish Lake, September 17, 1874	1,291.395

	Feet.
Bench mark on burr-oak stump 8 inches in diameter, right bank of Mississippi River, near town line, northeast corner township 145, range 27	1,300.617
Elevation of water in Mississippi River, at head of Small Rapids, 3 miles below Little Winnibigoshish, September 18, 1874	1,288.732
Elevation of water at foot of rapids, September 18, 1874	1,287.768
Elevation of water in Lake Winnibigoshish, August 20, 1874	1,292.869
Elevation of water in Lake Winnibigoshish, October 15, 1878	1,290.896
Elevation of water at Winnibigoshish, October 15, 1878	1,290.371
Bench mark on burr-oak stump 6 inches in diameter, 150 feet from water, on right bank of river, at outlet of Lake Winnibigoshish, first point below lake, and opposite Indian village	1,308.377
Water surface, lake in sections 3 and 10, township 146, range 26 west of the fifth meridian, December 31, 1880	1,298.370
Water in creek, 1 mile south of lake, January 1, 1881	1,305.359
Head of east branch of Cut Foot Sioux Creek, 1 mile from Bow String Lake, October 10, 1880	1,306.345
Height of land between Winnibigoshish and Bow String lakes	1,345.548
Water surface, Bow String Lake, October 10, 1880	1,321.102
Bench mark on jack pine 15 inches in diameter, 4 feet to right of trail between two marshes near Bow String Lake	1,344.561
Water surface in Mississippi River, at mouth of Horn River	1,298.377
Water in Horn Lake, October 1880	1,309.643
Elevation of water in Cass Lake at outlet, September, 1874	1,302.807
Bench mark on burr-oak stump 10 inches in diameter, 100 feet from lake, 500 feet north of mouth of river	1,305.881
Elevation of water in Cass Lake, jr., September 9, 1874	1,303.125
Bench mark on oak stump 6 inches in diameter, at Portage, from Cass Lake to Cass Lake, jr	1,305.984
Elevation of water in Mud Lake, September 29, 1874	1,282.733
Elevation of water in Mud Lake, October 4, 1878	1,280.725
Bench mark on line of Mud Lake dam-site, east side, 70 feet back from water, on balsam	1,285.533
Bench mark on line of Mud Lake dam-site, west side, 260 feet back from river, pine 14 inches in diameter	1,291.358
Water surface, Mississippi River, at Crow Wing, July 12, 1874	1,154.423
Bench mark on black-oak stump at Crow Wing, on river bank	1,156.661
Elevation of top of rail, North Pacific Railroad, at crossing of road from Brainerd to Leech Lake	1,204.525
Bench mark on pine stump, Leech Lake road, 1,000 feet north of railroad track	1,210.774
Water surface in Red Sand Lake, July 17, 1874	1,201.584
Bench mark on pine stump, 5 feet to right of center of road, 1,000 feet from Red Sand Lake	1,211.701
Water surface in Long Lake, July 18, 1874	1,200.363
Bench mark 30 feet left of road, 100 feet left of Long Lake	1,210.355
Water surface in outlet of Round Lake, July 18, 1874	1,195.946
Elevation of water in Gull Lake, July 18, 1874	1,195.733
Bench mark on elm tree 2½ feet in diameter, 5 feet to right of road, 165 feet from Gull Lake	1,202.146
Elevation of water in Lake Hubert, August 25, 1880	1,198.770
Elevation of water in Round Lake, August 25, 1880	1,195.077
Elevation of water in Mud Lake, August 25, 1880	1,195.423
Elevation of water in Gull Lake, August 14, 1880	1,194.410
Elevation of water in Moose Lake, September 29, 1880	1,226.235
Elevation of water in White Fish Lake, September 29, 1880	1,223.829
Elevation of water in Pig Lake, September 29, 1880	1,224.161
Elevation of water in Camp Lake, September 27, 1880	1,226.614
Elevation of water in Cullen Lake, August 27, 1880	1,196.150
Elevation of water in Sylvan Lake, August 20, 1880	1,201.403
Elevation of water at dam-site on Pine River, September 11, 1880	1,219.699
Bench mark on white-pine tree 2 feet in diameter, 1,000 feet below Cross Lake, 300 feet north of dam-site	1,219.696
Elevation of water in Rush Lake, September 10, 1880	1,222.382
Elevation of water in Hen Lake, September 10, 1880	1,224.964
Elevation of water in Upper White Fish Lake, September 10, 1880	1,223.973
Elevation of water in Lower Hay Lake, September 10, 1880	1,225.216
Elevation of water in Upper Gull Lake, above the dam, September 7, 1880	1,200.341
Bench mark on root of oak tree 18 inches in diameter, 200 feet north of old dam, at outlet of the main Gull Lake	1,199.171

	Feet.
Water surface of Pelican Lake, September 6, 1880	1,211.152
Water surface of Fish-trap Creek, July 19, 1874	1,196.352
Water in creek from Cullen Lake at road crossing, July 19, 1874	1,196.245
Bench mark on pine tree 14 inches in diameter, on north side of creek	1,197.908
Water surface south branch of Hay Creek at road crossing, July 21, 1874	1,242.875
Elevation of water in Hay Creek, July 21, 1874	1,238.475
Bench mark on jack pine 12 inches in diameter, 300 feet north of Hay Creek on left of road	1,247.839
Elevation of water in Pine River at road crossing, July 22, 1874	1,273.729
Bench mark on Norway-pine stump 3 feet in diameter, 25 feet north of Pine River, right of road	1,278.991
Height of land between Pine River and the south branch of Pine River, on the road to Leech Lake	1,368.995
Water surface, north branch of Pine River, July 24, 1874	1,322.971
Bench mark on Norway-pine stump 18 inches in diameter, left of road, one-fourth mile east of Mountain Pine Lake, one-half mile north of outlet	1,339.819
Water surface, Fourteen-mile Creek at road crossing, July 26, 1874	1,375.594
Bench mark on bowlder, with copper bolt, 467 feet north of creek, 125 feet left of road	1,388.551
Bench mark on Norway-pine tree 10 feet east of road, 12½ miles east from Leech Lake	1,428.755
Height of land, bench mark 24, about half way between Fourteen-mile and Leech lakes	1,499.894
Bench mark on bowlder, with copper bolt, at Leech Lake Indian Agency	1,298.691
Bench mark on bowlder with copper bolt, at Leech Lake trading post	1,300.132
High-water in Leech Lake, August 22, 1874	1,295.686
Low-water in Leech Lake, October 31, 1874	1,295.486
High-water in Leech Lake, August, 1878	1,294.261
Low-water in Leech Lake, October 16, 1878	1,293.761
Low-water in Leech Lake, November, 1879	1,293.661
High-water in Leech Lake, July, 1879	1,294.461
High-water in Leech Lake, September, 1880	1,294.761
Water surface in Bog River Bay, August 13, 1874	1,295.376
Water surface in Leech Lake River at portage from Bog River Bay, August 13, 1874	1,292.376
Height of land on Bog River portage trail	1,336.225
Bench-mark on Leech Lake River at end of portage trail from Bog River Bay, on tamarac stump, edge of timber	1,295.797
Water surface at outlet of Leech Lake, August 14, 1874	1,295.386
Bench mark on burr oak stump, 50 feet from Leech Lake, on section-line between sections 17 and 18, town. 144, range 28, west 5th meridian	1,303.584
Bench mark on Portage Lake, 2 feet in diameter, on Norway pine on left of Winnibigoshish trail	1,320.692
Elevation of water in Portage Lake, August 19, 1874	1,298.755
Height of land on trail from Leech Lake to Lake Winnibigoshish	1,324.068

MISSISSIPPI RIVER BELOW SAINT PAUL.

Junction of Saint Croix and Mississippi Rivers.

Water surface at Prescott, Wis., October 23, 1879	668.766
Bench mark at Prescott, Wis., water table, southeast corner of Guy's Hall	712.620

SAINT CROIX RIVER, MINNESOTA AND WISCONSIN.

Water surface, Lake Saint Croix, at mouth of Kinnickinnic River, October 18, 1879	667.892
Water surface at Stillwater, Saint Croix River, October 3, 1879	667.952
Bench mark on cottonwood stump 24 inches in diameter, 300 feet below Stillwater Railroad bridge, on left bank	679.015
Bench mark at North Hudson, on stone door-step, main entrance of brick building, general office of Chicago, Saint Paul and Minneapolis Railroad	704.244
Water surface in Saint Croix River at mouth of Apple River, September 20, 1879	672.169
Water surface in Saint Croix River at Osceola, Wisconsin, August 29, 1879	683.534
Bench mark at Osceola, 50 feet from water opposite center of elevator	687.135
Water surface in Saint Croix River at head of Rock Island, August 26, 1879	685.535
Bench mark on elm, right bank of river, 100 feet above the head of Rock Island	691.703

	Feet.
Water surface at Taylor's Falls, Wisconsin, at lower steamboat landing, August 25, 1879	687.102
Water surface, Saint Croix River, at Taylor's Falls, lower steamboat landing, September 25, 1880	686.740
Bench mark, head of iron ring with chain, at lower steamboat landing, Taylor's Falls, Wisconsin	702.649
Water surface, Saint Croix River, at mouth of Rock Creek, September 25, 1880	726.537
Bench mark, arrow head on bowlder, 250 feet south of Rock Creek Bridge	739.866
Water surface in Woolf Creek, above dam, at Ardinsinger's Mill, September 30, 1880	808.887
Water surface below dam, September 30, 1880	795.625
Bench mark on left side of door sill, Ardinsinger's Mill, on Woolf Creek	809.884
Water surface in Saint Croix River, at mouth of Trade River, September 22, 1880	753.270
Bench-mark on triple maple, north bank of Trade River, 20 feet from junction with the Saint Croix	756.931
Water surface in Trade River, 1,500 feet up stream from its mouth, September 22, 1880	757.089
Water surface in Saint Croix River at mouth of Sunrise River, September 21, 1880	758.489
Bench-mark arrow head on bowlder, 4 feet in diameter, at angle in road one-fourth mile north of Sunrise Ferry	778.656
Water surface at Deering's Ferry, at Rush City crossing of the Saint Croix River, September 17, 1880	770.531
Water surface at Rush City Ferry, June 6, 1879	772.963
Water surface in Rush Creek at Rush City, June 5, 1879	859.800
Bench mark top of tie, south end of railroad bridge at Rush City	916.000
Bench mark, bass-wood tree, 75 feet southwest Deering's Ferry Landing, on west bank of Saint Croix River	785.314
Bench mark, oak 18 inches diameter, 50 feet southeast of ferry, on east bank of Saint Croix River	782.390
Elevation of top of bluff on east bank of Saint Croix River at Deering's Ferry	877.197
Elevation of grade on Grantsburgh Railroad 4 miles from Saint Croix River crossing	878.207
Elevation of ground at Big Spring on the Saint Croix River road	881.981
Elevation of ground at Grantsburgh, Wis	903.224
Elevation of water in Wood River at Grantsburgh above the dam, June 9, 1879	881.656
Bench mark on pine stump 26 inches in diameter, 150 feet north of bridge, on left of road, Grantsburgh, Wis	897.965
Surface of ground at Marshland, Wis., June 10, 1879	945.454
Elevation of water in Clam River at road crossing Grantsburgh to Big Dam, June 10, 1879	881.344
Bench mark on bowlder 75 feet north from center of bridge, on line with right truss	891.629
Height of land between Clam and Yellow rivers	1,036.567
Elevation of water in Yellow River at road crossing Grantsburgh to Big Dam, June 12, 1879	927.799
Bench mark on bent jack oak 6 inches in diameter, on crest of hill above ferry at Yellow River, left bank of river	946.957
Height of land between Yellow River and Loon Creek	1,039.685
Water surface in Loon Creek at road crossing Grantsburgh to Big Dam, June 16, 1879	936.360
Bench mark, jack pine 8 inches in diameter, 12 feet right of road, north bank Loon Creek, 30 feet from bridge	942.415
Height of land between Loon Creek and Trout Brook	1,008.828
Water surface in Trout Brook at road crossing, June 17, 1879	919.833
Bench mark, white pine 2 feet in diameter, east end of Trout Brook Bridge	921.888
Height of land between Trout Brook and Namekagon River	1,009.091
Water surface, Namekagon River at road crossing, Grantsburgh to Big Dam, June 17, 1879	914.670
Bench mark, Norway pine 14 inches in diameter, top of bluff on south side of Namekagon River, on old road, 150 feet to right of main road	959.288
Height of land between Namekagon River and Saint Croix River, at Big Dam, on road from Grantsburgh to Big Dam	1,096.877
Water surface, Saint Croix River, above the Big Dam, on the Upper Saint Croix, June 20, 1879	1,005.311
Water surface below the Big Dam June 20, 1879	1,001.481

	Feet.
Bench mark on granite bowlder 4 feet in diameter, 75 feet south, 80° 20′ east, from the south end of the Big Dam, broad arrow cut in rock	1,013.215
Bench mark on highest point of bowlder on east shore of Eau Claire River, at Bayfield road crossing	1,029.080
Water surface in Willis Lake, October 16, 1878	995.690
Water surface in Saint Croix River at Moose River Rapids, September, 1878.	987.155
Bench mark on ash stub on bank of Saint Croix River at Moose River Rapids	991.226
Water surface Upper Saint Croix Lake, September, 1878	1,011.064
Bench mark on town line between sections 1 and 35 on the Upper Saint Croix Lake, balsam tree 6 inches in diameter	1,015.643
Water surface in Flag Lake, September, 1878	1,018.366
Elevation of springs at headwater of the Saint Croix River	1,070.043
Elevation of springs at headwaters of the south branch of the Brule River. (These springs rise in the same marsh, 600 feet apart; the Brule running north, the Saint Croix south.)	1,067.933
Water surface, Brule River, at head of canoe navigation	1,012.469
Elevation of water in Clam Lake	950.100
Water surface in Yellow Lake, October 31, 1878	926.637
Bench mark on Yellow River, at proposed dam-site, Norway pine 18 inches in diameter	958.759
Water surface in Bass Lake, October 31, 1878	940.779
Water surface in Fish Lake, November 6, 1878	959.680
Elevation of grade of North Wisconsin Railroad, at Yellow River Crossing, on north side of river	1,081.768
Bench mark on small pine, 100 feet north of river, 40 feet east of railroad at railroad crossing of Yellow River	1,072.353
Water surface upper Rice Lake, June 23, 1879	970.321
Bench mark, nail in lower end of door-sill, outside of jamb, of Benort's store-house at Rice Lake	976.082
Water surface at Rice Lake dam-site, June 24, 1879	969.408
Water surface lower Rice Lake, June 23, 1879	969.881
Water surface east Rice Lake, June 23, 1879	972.700
Water surface in Yellow River, three-fourths of a mile below Mud Lake, June 16, 1879	1,072.360
Water surface in Mud Lake, June 16, 1879	1,085.000
Water surface at junction of Namekagon and Totogatic rivers, Wisconsin, August 20, 1879	918.500
Bench mark, jack pine, 200 feet below the mouth of Totogatic River	962.540
Water surface in Namekagon River, at Viezie's Ranch, June 24, 1879	1,038.921
Bench mark on pine tree, back of store at Viezie's Ranch on the Namekagon River	1,076.105
Water surface in Bean Brook, at road crossing, June 25, 1879	1,056.480
Water in Namekagon River, at ford above Big Bend, June 25, 1879	1,056.593
Bench mark at ford, left bank of Namekagon River, 75 feet from water	1,063.162
Water surface, River Jordan, at Namekagon road crossing, June 25, 1879	1,057.974
Water surface in Spring Brook, at road crossing, June 25, 1879	1,069.278
Water surface in Hay Creek, at road crossing, June 25, 1879	1,069.275
Bench mark on white pine, 500 feet north of Hay Creek, Namekagon road	1,089.103
Water surface in Chipenacia Creek, above the dam, Namekagon road, June 27, 1879	1,127.020
Water surface, Chipenacia Creek, below the dam, June 27, 1879	1,122.524
Water surface, Namekagon River, 500 feet above Chipenacia Creek, June 27, 1879	1,115.341
Bench mark on white pine 20 inches in diameter, 500 feet above Chipenacia Creek, on bank of Namekagon River	1,128.111
Water surface, Dingwall Creek, at road crossing, June 28, 1879	1,177.701
Water surface in Little Pa-kwa-wang Lake, June 28, 1879	1,217.852
Bench mark at junction of Pa-kwa-wang and Totogatic roads, white pine 2 feet in diameter, left of both roads	1,231.038
Water surface in Totogatic River, at the proposed dam-site, section 13, town. 42, range 12, October, 1878	975.525
Bench mark on right bank of river, 50 feet from water, jack pine stump 6 inches in diameter, at proposed dam-site	1,004.578
Water surface in Gilmore Lake, October, 1878	997.219
Water surface in Duck Lake, October 16, 1878	989.949
Water surface in Leaf Lake, October 23, 1878	999.698
Water surface in White Fish Lake, October 22, 1878	1,030.696

	Feet.
Bench mark, jack pine 9 inches in diameter, between ponds at White Fish Lake	1,035.256
Water surface at Upper Totogatic Dam, above the dam, August 10, 1879	1,242.193
Water surface at Upper Totogatic Dam, below the dam, August 10, 1879	1,236.844
Bench mark, birch tree 1 foot in diameter, left bank, 200 feet from river 300 feet below the dam	1,257.175
Height of land on road between Cold Stream and Totogatic River	1,320.704
Water surface in Cold Stream at road crossing, August 12, 1879	1,250.225
Height of land between Cold Stream and Upper or Indian Crossing of the Totogatic River	1,351.511
Water surface at Indian Crossing of the Totogatic River, August 15, 1879	1,244.251
Bench mark at Indian Crossing of the Totogatic River, highest point of bowlder at foot of hill, 125 feet east of river	1,246.422
Height of land, on road between Totagatic and Namekagon rivers	1,306.662
Bench mark on door-sill of Antoine Gordon House at Amick on the Eau Claire River	1,034.531
Water surface in the Eau Claire River at Amick, upper side of bridge, August 3, 1879	1,012.558
Water surface in the Eau Claire River, 6 miles above Gordon's, on road to Eau Claire Lakes, August 3, 1879	1,073.981
Bench mark on Norway pine 15 inches in diameter, 30 feet left of road at same point	1,102.640
Water surface first Eau Claire Lake, above the old dam, August 4, 1879	1,120.096
Water surface in Eau Claire River, below the old dam, August 4, 1879	1,115.761
Bench mark on Norway pine 18 inches in diameter, at dam-site outlet of Eau Claire Lake	1,129.585
Water surface in second Eau Claire Lake, August 6, 1879	1,122.503
Bench mark on oak 8 inches in diameter on shore of second Eau Claire Lake, 200 feet west of outlet	1,123.020
Water surface in Saint Croix River, at the mouth of Snake River, September 13, 1880	798.569
Bench mark on bass-wood on right bank of the Saint Croix River, 400 feet below mouth of Snake River	806.116
Bench mark, floor of first gateway, from south bank of river, Changwatana Dam	929.674
Water surface in Cross Lake, at Pine City, August 18, 1880	933.174
Bench mark, door-sill, left side of main entrance of the Lake View House at Pine City, Minn	951.512
Water surface in Cross Lake, at Pine City, September 24, 1879	936.985
Water surface in Rice Creek on road from Pine City to Brunswick, September 25, 1879	937.152
Water surface Snake River at Millett's Rapids (foot of rapids), September 28, 1879	937.065
Water surface in Snake River, opposite the old court house at Brunswick, September 28, 1879	939.809
Bench mark on pine stump in front of Brunswick Court House	953.928
Water surface in Ground House River at bridge crossing to Brunswick, September 25, 1879	941.504
Water surface in Snake River at road crossing to Brunswick, September 25, 1879	941.252
Bench mark on dead pine on line with and 300 feet north of bridge at Brunswick	962.413
Water surface in Snake River at mouth of Ann River, September 26, 1879	943.124
Water surface in Snake River 1 mile below Knife River, at road crossing, September 27, 1879	958.620
Bench mark on white pine 28 inches in diameter 100 feet left of road at same point	982.845
Bench mark on road from Snake River to Mille Lacs, 250 feet west of Knife River Dam	1,049.436
Water surface Little Ann River at road from Snake River to Mille Lacs, 2 miles below dam, September 22, 1880	1.098.643
Bench mark on elm right of road, 75 feet east of Little Ann River at same point	1,103.586
Bench mark on bass wook 14 inches in diameter, 160 feet from Mille Lacs, near trail	1,256.887

Mississippi River above Saint Paul.

Bench mark on elm 10 inches in diameter, 35 feet from Mille Lacs, near trail to lake	1,253.153

	Feet.
Water surface in Mille Lacs, October 3, 1880	1,251.179
Height of land between Snake River and Mille Lacs, about 2½ miles southeast of lake on trail	1,299.434

Minnesota River.

Elevation of sun-dial at Fort Snelling	805.184
Bench mark on Chicago, Milwaukee and Saint Paul Railroad bridge, at Mendota, copper bolt in south pier, 1 foot west of center	714.538
Bench mark on elm tree, 150 feet from Bloomington Ferry, on right bank of Minnesota River	706.026
Bench mark on top of mile post, Saint Paul and Sioux City Railroad, marked 26 and 243	736.320
Water surface, Minnesota River, at Shakopee, August 10, 1874	690.696
Water surface, Minnesota River, at Chaska, August 17, 1874	690.776
Bench mark, copper bolt with cross-cut in rock, east abutment of draw-bridge, Chaska, Minnesota	721.167
Water surface in Minnesota River, at Carver, August 21, 1874	690.996
High-water of 1870, Carver, Minn	715.296
Bench mark, copper bolt, west pier, of draw-bridge, Carver, Minnesota River	720.017
Water surface, Minnesota River, at Jordan Ferry, September 8, 1874	692.616
Bench mark, ash stump, 2 feet in diameter, right of road, left bank of river, 175 feet from barn at Jordan Ferry	715.743
Water surface, Minnesota River, at Belle Plain, September 15, 1874	695.626
Water surface, Minnesota River, at Faxon, September 24, 1874	700.146
Water surface, Minnesota River, at Blakely, September 24, 1874	700.476
Water surface, Minnesota River, at Henderson, October 3, 1874	710.566
General level of ground at Henderson, Minn	727.106
Water surface, Minnesota River, at East Henderson, October 5, 1874	711.686
High-water mark at East Henderson	727.046
Water surface in Minnesota River, at Le Sueur, October 10, 1874	717.746
Bench mark on elm, top of right bank, at Upper Le Sueur Ferry	734.950
Water surface, Minnesota River, at Ottawa Ferry, October 14, 1874	722.816
Water surface, Minnesota River, at Traverse Des Sioux, October 16, 1874	725.956
Bench mark on cottonwood, 200 feet from river, left bank, at Traverse Des Sioux	748.098
Water surface, Minnesota River, at Saint Peter, October 19, 1874	630.136
Bench mark, copper bolt, north end of Capstone, west abutment of bridge at Saint Peter	660.469
Water surface, Minnesota River, at Mankato, November 4, 1874	752.506
High-water mark on high-way bridge pier, at Mankato	778.546
Bench mark, copper bolt in foundation of Shauburt's building, corner of Front and Main streets, Mankato	779.060
Water surface, Minnesota River, at mouth of Blue Earth River, November 4, 1874	756.139
Bench mark on cottonwood, 2 feet in diameter, left bank of Minnesota River at Mankato Ferry	766.135
Bench mark on cottonwood stump, with copper bolt, above South Bend, Minnesota River	772.606

Red River of the North.

Bench mark top of initial post at junction of Bois Des Sioux and Otter-Tail rivers	961.950
Bench mark on west door-sill, Woodson's house, at Waupaton, opposite Breckinridge	961.655
Water surface, Red River, at Breckinridge, Minnesota, October 3, 1880	942.911
Water surface Red River at Fort Abercrombie, October 5, 1880	909.790
Surface of ground at Fort Abercrombie	936.727
Bench mark top of first United States reservation post, up river	947.299
Bench mark, top of second United States reservation post, down river, on river bank	939.771
Water surface Red River at mouth of Wild Rice River, October 6, 1880	874.666
Bench mark on root of small elm at mouth of Wild Rice River, 50 feet south	887.859
Bench mark on ash stump, south side of Wild Rice River	888.684
Bench mark elm tree on levee at Moorhead, Minn	879.157
Water surface at Moorhead, October 8, 1880	868.933

	Feet.
Water surface at Moorhead, August 8, 1873	870.721
High-water mark in Red River on pier of railroad bridge	899.043
General elevation of ground at Moorhead	903.010
Bench mark top of rail North Pacific Railroad bridge at Moorhead	904.894
Elevation of water in Red River at mouth of Cheyenne River, August 26, 1873	856.806
Bench mark, elm stump at mouth of Cheyenne River	870.394
Water surface in Elm River, near mouth, September 8, 1873	837.767
Water surface in Goose River, near mouth, at Caledonia, September 15, 1873	823.963
Water surface at foot of Goose Rapids, September 15, 1873	818.631
Bench mark on southeast corner of foundation of Meckelson's farm-house, at Goose Rapids	862.372
High-water mark in Red River at Meckelson's	853.294
Water surface, Red River, at Frog Point, October 8, 1873	808.325
Bench mark on foundation southeast corner of hotel at Frog Point	861.557
High-water of 1873, at Frog Point	845.467
Elevation of ground at Grand Forks, Dak	830.393
Bench mark on big elm tree 2 feet in diameter, 1,600 feet below Grand Forks	812.294
Water surface in Red River, 1,600 feet below Grand Forks, July 18, 1877	806.118
Water surface at Brown's Bar, July 25, 1877	799.017
Bench mark on oak 18 inches in diameter on bank of river near Brown's house	818.766
Water surface, Turtle River, August 11, 1879	780.707
Bench mark on box-elder 16 inches in diameter, 150 feet from mouth of Turtle River, up stream	809.913
Water surface in Salt River, Dakota, at stage-road crossing, August 15, 1877	784.111
Bench mark on oak tree 28 inches in diameter, 150 feet from bridge at stage road crossing of Salt River, Dakota	797.890
Water surface, Red River, at Kelley's Point, August 16, 1877	773.602
Bench mark on southeast corner of Jirard's house, at Kelley's Point	802.534
Water surface at road-crossing of Little Salt River, Dakota Territory, August 17, 1877	770.681
Bench mark on dry oak tree 18 inches in diameter, 100 feet left of road, at crossing of Little Salt River	796.807
Water surface in Red River at the mouth of Pembina River, August 30, 1877	753.503
Bench mark on northeast corner of foundation of N. Myrick's store, Pembina, Dak	790.013
Bench mark on big oak post, 200 feet from east side of fence inclosing Fort Pembina	791.576
Elevation of ground at Fort Pembina, Dak	787.571

Chippewa River, Wisconsin.

Water surface, Chippewa River, at the mouth, September 29, 1874	659.405
Bench mark on black birch at mouth of Chippewa River	660.971
Water surface, Chippewa River, at outlet of Dead Lake, September 23, 1874	684.225
Water surface, Chippewa River, at Durand, September 16, 1874	691.095
Bench mark on black oak east of road, 300 feet north of Niles' House at Durand, Wis	758.725
Water surface, Chippewa River, at the mouth of Red Cedar River, September 12, 1874	704.935
Water surface in Chippewa River, at the mouth of the Eau Claire River, April 9, 1881	751.331
Bench mark southwest corner of porch of J. W. McKay's house, at mouth of Eau Claire River	766.477
Bench mark top of tie main track West Wisconsin Railroad, opposite passenger depot, Eau Claire	827.416
Water surface at foot of Lower Dalles, Chippewa River, August 24, 1874	756.246
Water surface at head of Lower Dalles, August 24, 1874	762.845
Water surface at foot of Upper Dalles, August 18, 1874	778.225
Bench mark on pine, right bank of river, opposite and 500 feet above Barnes' Mill, at foot of Upper Dalles	790.131
Water surface at head of Upper Dalles, Chippewa River, August 18, 1874	787.712
Water surface, Chippewa River, at Chippewa Falls, below ferry landing, August 18, 1874	792.239
Bench mark, spike head, first pier from right bank of county bridge at Chippewa Falls	832.565

	Feet.
Water surface in Flat Lake, October 29, 1879	1,320.300
Water surface in Sand Lake, October 29, 1879	1,301.100
Water surface in Fish Lake, October 16, 1879	1,289.113
Water surface in Island Lake, October 16, 1879	1,291.993
Water surface in Grindstone Lake, October 11, 1879	1,287.647
Water surface, lower Lac Courtes Oreilles, October 6, 1879	1,286.397
Bench mark on point of rock south of outlet, from upper into lower Lac Courtes Oreilles	1,291.700
Water surface, Lac Courtes Oreilles, October 5, 1879	1,287.140
Bench mark, Norway pine, 18 inches in diameter, south shore of Lac Courtes Oreilles, October 6, 1879, 1 mile east of village	1,294.532
Elevation of water in Lost Lake, September, 1879	1,385.000
Elevation of water in Cross Lake, September, 1879	1,384.800
Elevation of water in Summer Lake, September 22, 1879	1,396.055
Bench mark, hemlock, 18 inches in diameter, at outlet of Summer Lake	1,398.754
Water surface, Partridge Crop Lake, September 22, 1879	1,384.740
Bench marck, birch, 18 inches in diameter, on right bank of outlet of Partridge Crop Lake	1,391.549
Water surface in Moose Lake, September 13, 1879	1,362.357
Water surface below dam at Moose Lake, September 4, 1879	1,358.670
Water surface above dam at Moose Lake, September 4, 1879	1,361.793
Bench mark on dead white pine, 25 feet above dam	1,364.563
Water surface, west fork of Chippewa River, at mouth of Lea River, September 4, 1879	1,352.751
Bench mark on white pine, 12 inches in diameter, at the mouth of Tea River	1,356.248
Water surface in Chief Lake, September 1, 1879	1,295.739
Bench mark, Norway pine, 14 inches in diameter, 50 feet right of road, 50 feet from Chief Lake, 200 feet west of bridge at southeast corner of lake	1,300.359
Water surface, Little Chief River, below dam, August 19, 1879	1,292.714
Water surface, Little Chief River, above dam, August 19, 1879	1,293.778
Water surface in Pokegama Lake, August 11, 1879	1,290.515
Water surface in Little Chief River, at the forks, August 18, 1879	1,288.493
Water surface, Pa-kwa-wang Lake, July 31, 1879	1,286.091
Bench mark on pine, 12 inches in diameter, on bank of Pa-kwa-wang Lake, 200 feet north of Indian Village	1,289.731
Water surface, Hunter's Lake, July 18, 1879	1,326.962
Water surface, Little Chief Lake, at Baker's farm, July 19, 1879	1,324.947
Bench mark on maple stump in hay-field, 100 feet north of old barn at Baker's farm	1,350.073
Water surface at Snaptail Rapids, Chippewa River, July 17, 1879	1,346.011
Water surface at head of Snaptail Rapids, Chippewa River, July 17, 1879	1,368.760
Bench mark on birch tree, 50 feet below the head of Snaptail Rapids	1,374.734
Water surface at foot of Cedar Rapids, June 23, 1879	1,403.883
Water surface at head of Cedar Rapids, Chippewa River, June 23, 1879	1,420.044
Bench mark on hemlock, 70 feet from right bank of Chippewa River, at pool below Cedar Rapids	1,410.365
Water surface above dam on Chippewa River, in section 26, township 41, range 4 west, fourth meridian, June 21, 1879	1,433.104
Water surface below dam at same point in the Chippewa River, June 21, 1879	1,429.549
Bench mark on pine tree at east end of dam	1,443.825
Water surface, Bear Lake, June 20, 1879	1,433.694
Bench mark at head of bay, in Bear Lake, 60 feet from water, on cedar stump	1,437.580
Water surface, Chippewa River, in southwest quarter of the northeast quarter of section 28, township 41, range 3 west, fourth meridian, June 19, 1879	1,441.904
Water surface in the Chippewa River, at the Wisconsin Central Railroad crossing, June 11, 1879	1,509.332
High-water in Chippewa River, at Wisconsin Central Railroad crossing, May 14, 1879	1,516.056
Bench mark, elevation of top of tie over first cap at south end of Wisconsin Central Railroad bridge over Chippewa River	1,522.500
Low-water at railroad crossing of the Flambeau River, 1878	1,445.000
Bench mark, top of rail, center of Howe Truss Bridge at Flambeau crossing, Muskalonge Falls	1,463.529
Water surface, Flambeau River, below Muscalonge Falls, November 3, 1878	1,446.000
Water surface in Flambeau River, above Muskalonge Falls, November 3, 1878	1,458.291

	Feet.
Water surface, Flambeau River, at mouth of Turtle River, October 28, 1878	1,525.546
Bench mark, ash stub, 6 feet from edge of water at junction of Flambeau and Turtle rivers	1,530.175
Water surface, Flambeau River, at the forks of Manitouish and Bear Creeks, October 24, 1878	1,552.567
Bench mark on top of oak stump, 6 inches in diameter, on right bank of Flambeau, opposite the forks	1,557.813
Water surface in Rest Lake, September 24, 1878	1,571.541
Bench mark on pine tree at Rest Lake, dam-site	1,591.833
Water surface in Flambeau Lake, October 2, 1879	1,562.245
Bench mark on small pine tree, at northeast end of Flambeau Lake	1,568.231
Water surface, Pokegama Lake, September 25, 1879	1,562.318
Water surface in Long Lake, September 25, 1879	1,562.345
Bench mark, small Norway pine, on Long Lake	1,565.983
Water surface in Crawling Stone Lake, September 22, 1879	1,562.245
Water surface in Fence Lake, September, 1879	1,562.813
Bench mark on Norway pine, 50 feet west of trail, 100 feet from south end of Fence Lake	1,574.674
Water surface in Round Lake, October 13, 1879	1,532.362
Bench mark on pine root, south end of Round Lake Dam	1,539.665
Elevation of sill of large sluice-way at Round Lake Dam	1,528.222
Elevation of top of gate, Round Lake Dam	1,532.714
Water surface in Big Lake, November 5, 1878	1,593.926
Bench mark, pine tree on Indian trail between Island and Big Lakes	1,596.756
Water surface in Little Manitouish Lake, November 1, 1878	1,574.804
Water surface in Island Lake, November 1, 1878	1,576.976
Water surface in Big Manitouish Lake, October 25, 1878	1,574.886
Bench mark on elm tree on Big Manitouish Lake	1,578.613
Water surface in Dole Lake, October 26, 1878	1,577.756
Water surface in Mud Lake No. 1, October 28, 1878	1,576.637
Water surface in Mud Lake No. 2, October 28, 1878	1,578.874
Water surface in Trout Lake, November 1, 1878	1,593.422
Water surface in Bowlder Lake, November 5, 1878	1,609.849
Bench mark on pine tree between Crooked and Bowlder Lakes, near shore of Bowlder Lake	1,622.653
Water surface in Crooked Lake, November 5, 1878	1,623.475
Bench mark on fir tree, near Crooked Lake, between Boulder and Crooked Lakes	1,626.919

Wisconsin River.

Water, surface below Pelican Dam, June 26, 1879	1,521.907
Crest of Dam at Pelican Lake	1,535.712
Sill of Pelican Dam	1,524.847
Water surface in Pelican Lake, July 14, 1879	1,527.917
Water surface, Wisconsin River, at foot of Rainbow Rapids, August 5, 1879	1,545.547
Water surface above Rainbow Rapids, August 5, 1879	1,549.897
Water surface, Wisconsin River, at foot of Otter Rapids, August 8, 1879	1,562.587
Bench mark, on pine root, north end of dam at Otter Rapids	1,599.793
Bench mark at junction of road to Otter Rapids and Portage trail to Tomahawk Lake, 20 feet west of road, 400 feet south of Portage trail	1,588.408
Bench mark on pine root, north end of dam at Otter Rapids	1,599.793
Water surface below the dam at Otter Rapids, August 8, 1879	1,578.193
Sill of gate at Otter Rapids Dam	1,579.443
Top of gate at Otter Rapids Dam	1,587.143
Top of Otter Rapids Dam	1,591.073
Water surface above Otter Rapids Dam, August 15, 1879	1,580.043
Water surface, Eagle Lake, August 15, 1879	1,583.066
Water surface, Catfish Lake, August 15, 1879	1,583.056
Water surface, Cranberry Lake, August 15, 1879	1,583.593
Water surface, Long Lake, August 16, 1879	1,593.333
Bench mark on white-pine root, 100 feet west of inlet to Long Lake	1,596.972
Water surface, Planting Ground Lake, August 17, 1877	1,592.399
Water surface, Island Lake, August 17, 1879	1,592.364
Bench mark, white-pine root, 100 feet west of outlet of Island Lake	1,597.895
Water surface, Fish Lake, August 18, 1879	1,592.365
Bench mark, white-pine root, 120 feet west of outlet of Fish Lake	1,595.487
Water surface, Medicine Lake, August 18, 1879	1,592.388
Water surface, Big Lake, August 19, 1879	1,592.569

The sum of $100,000 can be profitably expended during the fiscal year ending June 30, 1883, in carrying on this much needed public work.

The Red River of the North is wholly within the customs district of Minnesota, and Pembina the only port of entry, and chief port of the customs district.

The collection of duties and miscellaneous revenues at the port of Pembina and Saint Vincent Station during the fiscal year ending June 30, 1881, amounted to $12,057.06, and the value of exports of American goods at said port and station during said period amounted to $1,450,087.

For commercial statistics of the Red River between Boundary Line and Abercombie, Dakota Territory, see annual report for improving Red River of the North, Minnesota and Dakota:

Money statement.

Amount appropriated by act approved March 3, 1881	$20,000 00
July 1, 1881, amount available	20,000 00
Amount (estimated) required for completion of existing project	180,000
Amount that can be profitably expended in fiscal year ending June 30, 1883	100,000 00

W 9.

RESERVOIRS UPON THE HEADWATERS OF THE MISSISSIPPI RIVER AND ITS TRIBUTARIES, INCLUDING EXPERIMENTAL DAM AT LAKE WINNIBIGOSHISH.

The report for fiscal year ending June 30, 1880, in noting the appropriation made by act of Congress approved June 14, 1880, as follows—

For the reservoirs at the headwaters of the Mississippi River, to be used in the construction of a dam at Lake Winnibigoshish, seventy-five thousand dollars; *Provided*, That all injuries occasioned to individuals by overflow of their lands shall be ascertained and determined by agreement or in accordance with the laws of Minnesota, and shall not exceed in the aggregate five thousand dollars.—

stated that it was proposed, with the funds appropriated, to construct a dam of timber and earth, so as to raise the lake to a level of about 16 feet above low-water. Plans were matured during the months of July and August following, but owing to the opinion rendered by the Honorable Attorney-General, under date of August 13, to the effect that the act of Congress ordering the dam did not authorize the Indians of the Leech Lake Agency to dispose of material, or the United States to acquire occupancy with its perquisites, no work of construction could be undertaken.

The report of Captain Allen, January 16, 1881, in continuation of former reports, placed the cost of the proposed system of reservoirs (*exclusive* of cost of damage to land and other property) at $1,809,083.50.

The object of the reservoirs, to collect surplus water, as well as winter and spring precipitation, in sufficient quantity to be released in a systematic and methodical manner to benefit navigation upon the reaches of the several streams below the dams, and ultimately of the main Mississippi, *when taken in connection with other works of improvement upon the latter*, for a considerable distance below Saint Paul.

Alleviation of effects of floods, in localities near the proposed reservoirs, expected to obtain to some extent.

Control of extended floods or freshets, covering long reaches of river, not expected. In order that benefit to navigation may obtain upon the Mississippi above the mouth of the Saint Croix, the Saint Croix, the

Chippewa, the navigable reaches of the Wisconsin,* the system of dams proposed for such, should be carried out, and no benefit of any consequence to the Mississippi below Lake Pepin can be predicted unless the entire system is carried out. The plans and estimates presented in the various reports upon surveys and examinations for reservoirs, to date, have not, by any means, exhausted the subject.

The reservoirs, to be of maximum public benefit, must be operated in the interest of navigation, and not be diverted from that purpose.

Congress, by act approved March 3, 1881, appropriated $150,000 in addition to the sum appropriated in 1880, the total by the two acts amounting to $225,000, the act March 3, 1881, reading:

> For reservoirs upon the headwaters of the Mississippi River and its tributaries, one hundred and fifty thousand dollars, and this sum, together with the sum of seventy-five thousand dollars, heretofore appropriated for the construction of a dam at Lake Winnibigoshish, shall be expended at such places on said headwaters of the Mississippi River and its tributaries as the Secretary of War shall determine; and it is provided that compensation for any private property taken or appropriated for any of said improvements, and all damages to private property caused by the construction of any of said dams, by flowage or otherwise, shall be ascertained and determined under and in accordance with the laws of the State in which such private property is situated.

With this sum it is proposed, at this present writing, to begin the construction of dams at the outlets of Lake Winnibigoshish and Leech Lake sources of the Mississippi River as soon as the questions of damages from overflow, occupation, &c., can be settled. No benefits to navigation can be expected from the construction of but two dams of the system proposed.

If this work is to continue, the sum of $750,000 can be profitably expended during the fiscal year ending June 30, 1883, providing legal difficulties be removed.

The principal difficulties encountered thus far, have been—

1. Inadequacy of legislation affecting Indian reservations.
2. Omission in statutes, Minnesota and Wisconsin, providing for condemnation of land for United States purposes.
3. Absence of legislation, Minnesota, with reference to State lands of any kind liable to damage from overflow.
4. Failure of act of Wisconsin legislature to specify, or propose, distinctly, in act approved March 16, 1880, withdrawing from sale State lands liable to damage, &c., terms of settlement for such with the United States.

For commercial statistics, reference is made to reports, Falls of Saint Anthony, Mississippi River, above the Falls; Saint Croix River and Chippewa River, Wisconsin.

Money statement.

July 1, 1880, amount available	$75,000 00	
Amount appropriated by act approved March 3, 1881	150,000 00	
		$225,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,700 48	
July 1, 1881, outstanding liabilities	414 61	
		2,115 09
July 1, 1881, amount available		222,884 91
Amount (estimated) required for completion of existing project		1,584,083 50
Amount that can be profitably expended in fiscal year ending June 30, 1883		750,000 00

*Opinion as to benefits to the Wisconsin and Mississippi below Saint Paul are stated with some reluctance, the improvement of those streams not being in charge of the Saint Paul office.

REPORT OF A BOARD OF ENGINEER OFFICERS UPON THE PROJECT SUBMITTED BY CAPT. C. J. ALLEN, CORPS OF ENGINEERS, FOR THE CONSTRUCTION OF A DAM AT THE OUTLET OF LAKE WINNIBIGOSHISH.

SAINT PAUL, MINN., *August* 5, 1880.

Report of the Board of Engineer Officers constituted by Special Orders No. 90, Headquarters Corps of Engineers, United States Army, Washington, D. C., July 24, 1880, the order reading as follows:

[Extract.]

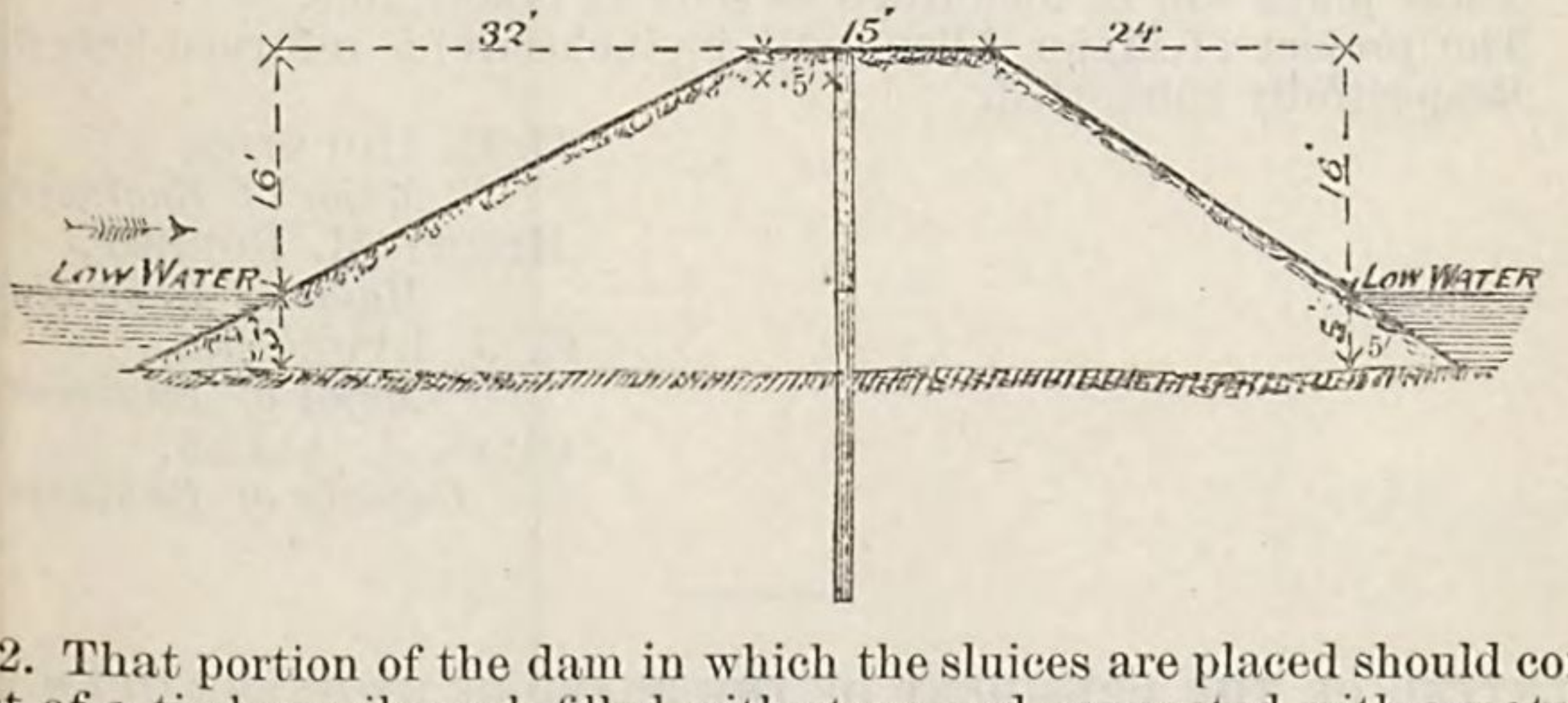
1. A Board of Officers of the Corps of Engineers, to consist of Maj. D. C. Houston, Maj. H. M. Robert, Maj. G. J. Lydecker, and Capt. C. J. Allen, will convene at Saint Paul, Minn., upon the call of the senior officer, at as early a day as practicable consistent with the other duties of the members, for the consideration of a project for a dam at the outlet of Lake Winnibigoshish, on the Mississippi River, proposed by Capt. Chas. J. Allen, Corps of Engineers.

The Board will report their opinion of the plan, with any modification in location, dimensions, mode of construction, and other matters connected therewith, which they may have to suggest.

The Board met at Saint Paul at 10 a. m. on August 3, 1880, and continued its sessions until the 5th.

The Board has carefully considered the project of dam at the outlet of Lake Winnibigoshish on the Mississippi River proposed by Major Allen, and is of the opinion that the plan and location will meet the requirements of a reservoir dam at that point, but after discussion of the subject would recommend the following modifications in dimensions and mode of construction.

1. The width of the earthen embankment may be safely reduced to 15 feet at top as a maximum, and the down-stream slope made 1 on $1\frac{1}{2}$, the proposed interior diaphragm being placed from 3 to 5 feet back from the interior crest. The general section of this embankment would then be as indicated in the following sketch:



2. That portion of the dam in which the sluices are placed should consist of a timber crib-work filled with stone and connected with a water-tight platform on a grillage and pile foundation. This character of structure will be simple in construction, readily repaired, and the portion above water can be easily replaced by masonry in the future; its top is made 14 feet above low-water (that of the embankment being 16 feet), and the work will serve as a waste weir when the water surface in the reservoir reaches that elevation; the connection of continuous wooden surfaces with earth-work is avoided as far as practicable. The general dimensions and plan of this work to be in accordance with sketches and memoranda furnished by the Board to the officer in charge of the work.

It is not deemed advisable to use kyanized or creosoted timber in this crib, which should eventually be replaced by a masonry structure. It is suggested that this sluice should be located nearer to the center of the entire dam if it be found that the nature of the ground is adapted to placing the foundation in a pit excavated to the proper level; in this way expensive coffer dams may be avoided, while the material excavated from the pit and from the new channel leading to the sluices may be used in the embankment so far as suitable for that purpose.

The cost of the work will not be increased by the proposed modifications.

In regard to the manner of doing the work the Board is of opinion that, owing to the lateness of the season, the remote locality of the proposed dam, the necessity of providing an entire plant, transporting all labor and supplies to the vicinity, and constructing quarters, &c., very little can be done before winter in hastening the time of completing the dam. This cannot be accomplished before the low-water of next season, whether the work is done by contract or hired labor. The timber can be best and most economically obtained during the winter. In view of the provisions of the river and harbor act making an appropriation for this work the Board is of opinion that it should be carried on by contract, and that proposals be advertised for as soon as the questions connected with the overflow of land and the right of the Engineer Department to take timber and other materials from the Indian reservation are decided on by the authorities. The government has no greater facilities for carrying on this work than private parties, and while it is possible that the work could be better done by hired labor than by contract, it is not possible to say that it cannot be done by contract "without detriment to the interests of the government," as required by the law. The Board would therefore recommend that detailed plans and specifications for the dam be prepared by the officer in charge of the work, in accordance with the foregoing recommendations, with a view to doing the work by contract.

These plans will be forwarded as soon as practicable.

The project of Major Allen (with its inclosure) is returned herewith.

Respectfully submitted.

D. C. HOUSTON,
Major of Engineers.
HENRY M. ROBERT,
Major of Engineers.
G. J. LYDECKER,
Major of Engineers.
CHAS. J. ALLEN,
Captain of Engineers.

LETTER OF THE PRESIDENT OF THE BOARD OF ENGINEER OFFICERS.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wis., December 21, 1880.

GENERAL: I have the honor to forward herewith a tracing, with description, showing details of modification of plan of reservoir dam at Lake Winnibigoshish, Minnesota, recommended by the Board of Engineers constituted by Special Order No. 90, par. 1, Headquarters Corps of Engineers, Washington, D. C., July 24, 1880, in their report dated August 5, 1880, to accompany said report.

RESERVOIR-DAM
LAKE WINNIBIGOSHISH
MINNESOTA

SHOWING

MODIFICATION of PLAN

Recommended by the Board of Engineers constituted by Special Orders No 80 Head Quarters Corps of Engineers July 28th 1880 in their report of August 5th 1880.

S. G. Goodrich
Brig. Maj. Gen. Ch. Engr.

Henry M. Robert
Major Engrs

D. C. Houston
Maj. Corps Engrs U.S.A.

Chas. J. Allen
Capt. of Engrs U.S.A. Asst. Maj. U.S.A.

LONGITUDINAL SECTION
SCALE ½"-1'

PLAN

Embankment

Crib Work

Log Sluice

Apron

CROSS-SECTION OF EMBANKMENT
Scale 1"-8'

FRONT ELEVATION OF GATE
SCALE ½"-1'

SECTION on line C-D
SCALE ½"-1'

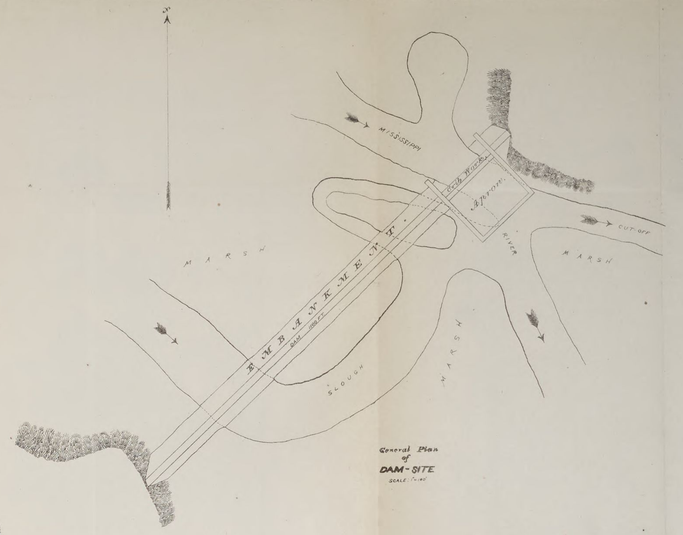
SECTION on line A-B
SCALE ½"-1'

LOW WATER

Log Sluice

Stone

Apron

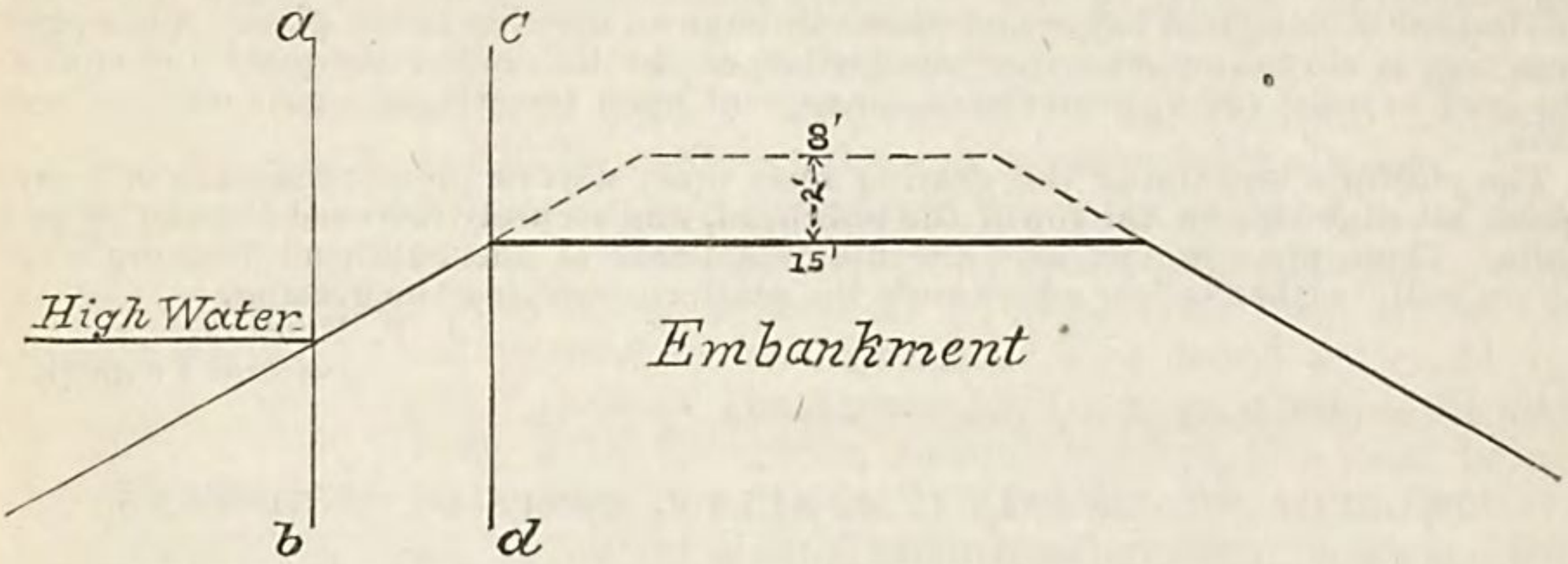


General Plan of DAM-SITE
SCALE 1"=40'

HOISTING GEARING
SCALE 1½"-1'

DETAIL OF SCREW
SCALE 6"-1'

Since the report of the Board was forwarded, a question has been raised as to the proper height of the embankment forming the main portion of the dam. Its top is placed 2 feet above high-water in the reservoir, the same as in Major Allen's original project. As a protection against waves I am of the opinion that the top of the embankment should be raised, as shown by the dotted lines on the sketch below, or that a wall or strong fence be constructed, as indicated by the line *a b* or *c d*. This suggestion does not call for any change in the plan as presented.



I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers,
Bvt. Colonel, U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

DESCRIPTION OF THE DAM FOR LAKE WINNIBIGOSHISH, DESIGNED IN ACCORDANCE WITH THE REPORT OF A BOARD OF ENGINEERS, DATED SAINT PAUL, AUGUST 5, 1880.

SAINT PAUL, *December* 14, 1880.

The dam site is a bed of clay overlaid to a depth of 3 to 5 feet by mud, and underlaid, at a depth of 10 to 15 feet, by sand. The body of the dam consists of an earth embankment 15 feet wide on top, with interior slope of one-half, exterior of two-thirds. The interior slope is covered with a heavy pavement embedded in a layer of broken stone or beach gravel. The foot of the exterior slope, so far as it is exposed to the action of water, is protected by similar pavement. A wooden diaphragm, or row of sheet piling, extends through the embankment lengthwise, reaching from the top down to the clay.

The part occupied by the sluices is composed of crib-work, the embankment being interrupted and sustained by abutments of crib-work. A bulkhead of crib-work containing the sluices reaches from one abutment to the other. It is 24 feet thick at bottom and rises to a height of 14 feet above low-water, that is, to within 2 feet of the top of the embankment, this being the arrangement prescribed in the above mentioned report. According to the same report the bulkhead is expected, at times, to serve as a waste-way. With this view it is arranged to break the fall of the water into two steps. The waste-way will be about 140 feet long. The sluices are twenty in number, each 5 feet wide and 5 feet high. They are separated from each other by walls of timber 2 feet thick, formed of 12-inch square timber lined with 6-inch plank. The exterior space between the abutments is occupied by an apron which extends about 120 feet below the mouth of the sluices, and is surrounded by walls of crib-work rising nearly to the height of low-water, forming an immense swash-basin for destroying the commotions of the water.

The abutments, bulkhead, and apron rest upon piles. A row of sheet-piling extends along the upper face of the bulkhead, and another along the lower or down-stream face.

One end of the bulkhead is occupied by a log sluice. This is opened by lowering the gate instead of raising it. The top of the gate is jointed to a movable apron over which the logs are carried. The gate descends into a recess on the up-stream face of

the bulkhead. This arrangement admits of using the sluice at different stages of the water without discharging too great a volume. The velocity with which the logs leave the sluice will be destroyed by passing a considerable distance through still water before reaching the opposite wall of the swash-basin.

The gates of the log and discharging sluices are of thick plank. They move in vertical grooves and are raised and lowered by screws, two to each gate. These are articulated to lugs on the upper edge of the gate, each of which is is confined by two long bolts, reaching, edgewise, through all the planks of the gate and fastened by nuts at the bottom. The screws are worked by toothed gear, or, more properly, by toothed nuts, the hub of the gear being provided with an internal thread through which the screw works; each pair of gears is worked by a single pinion and hand-wheel. Each set of gears has its bearings in a cast-iron plate fastened to the wood-work. The hub of the gear is elongated below and passes through an opening in the plate. A wrought-iron ring is shrunk or otherwise confined upon the hub below the plate and enables the gear to resist the upward thrust consequent upon lowering the gate under a pressure.

The platform sustaining the gearing rests upon narrow piers, consisting of 6-inch plank set edgewise on the top of the bulkhead, and securely fastened thereto by long bolts. These piers project over the up-stream face of the bulkhead, forming what sailors call "catheads," on which rests the platform carrying the gearing.

J. P. FRIZELL,
Assistant Engineer.

PROJECT OF CAPTAIN C. J. ALLEN, CORPS OF ENGINEERS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., July 16, 1880.

GENERAL: I have the honor to present the following project for the application and expenditure of the sum appropriated by act of Congress approved June 14, 1880, for the construction of an experimental dam at the outlet of Lake Winnibigoshish, the act reading:

> For the reservoirs at the headwaters of the Mississippi River, to be used in the construction of a dam at Lake Winnibigoshish, seventy-five thousand dollars: *Provided*, That all injuries occasioned to individuals by overflow of their lands shall be ascertained and determined by agreement or in accordance with the laws of Minnesota, and shall not exceed in the aggregate five thousand dollars.

In my letter to the department of the 30th ultimo, some suggested difficulties were mentioned as regards the settlement of damages to overflowed lands. These lands are all situated upon the Chippewa Indian Reservation, and are lands, as understood, the occupation of which is guaranteed to the Indians by treaty. Still, upon consideration since my letter of the 30th ultimo, it appears that these Indians do not own the land in fee-simple, they having merely the right of occupancy; and the fact of Congress ordering the improvement, and the implied occupation by overflow, the extent of which has been stated approximately in all the reports from this office to date, of certain lands within this reservation, seems to make it unnecessary to dwell longer upon the damage to land. Whether the Indians can sell stumpage so as to allow the United States to cut down the necessary amount of timber for the dams is a question that I do not pretend to pass upon. But if Congress orders the occupation by overflow of certain lands, does not the right follow to cut and use the timber from the same? Also to use bowlders, excavate earth (from borrow pits), &c., from any point of the reservoir? Bowlders are of no use to the Indians; the removal of the same from their lands would, if the lands belonged to them, benefit their property. The improvement of a road or trail covering portages, although benefiting the reservation interests, might, come under the same doubt. On the contrary, it is probable that the act of Congress ordering the work covers everything necessary to its prosecution. I have been assured by members of Congress that the appropriation for the

Winnibigoshish Dam is but the inauguration of the reservoir system for the entire country that has been under examination.

I append herewith a copy of report of Mr. J. P. Frizell, assistant engineer, upon a special examination of various points within the reservation, made in June last. It is sent as elucidating, in many respects, the difficulty of conducting work in that region. (Please see lithographed maps accompanying my reports of December 12 and January 15, last.)

The first estimate for the cost of this dam was made by Major Farquhar, under date of February 4, 1875, the cost being placed at $59,969.80. It is here supposed that the dam, being considered a part of a system, its cost was placed lower than if it were to be an isolated dam, the "plant" for which would be useless after completion of the work.

The second estimate was made by myself in report under date of January 15, 1879, printed as House Ex. Doc. No. 54, Forty-fifth Congress, second session, the cost being placed at $70,000—the dam to be experimental, but a component of the system. The third estimate, by myself, in report under date of December 12, 1879, printed as House Ex. Doc. No 39, Forty-sixth Congress, second session, the cost being placed at $80,000; the outlay for "plant" to be chargeable pro rata to other reservoirs when the latter should be ordered and appropriated for.

So many items enter into the consideration of the construction of this first dam that it will be impossible to prosecute it by contract. Day labor and purchase of materials in open market are recommended.

It is proposed to raise the dam to a height of from 14 feet to 16 feet above the lowest water known; to construct the main part of it of well-rammed earth, the slopes protected against action of waves and overflow, when the latter occurs in storms, by rip-rapping lined with several inches gravel, McAdam spalls, &c. A diaphragm of timber, 9 inches in thickness, to extend longitudinally throughout the extent of the dam, and to be continuous excepting where interrupted by the group of sluices, twenty in number, the area of cross-section of each to be 25 square feet, and height in the clear, 5 feet. The entire area of discharge to be 500 square feet. When the difference of level gets as low as 2 feet, the discharge will be, leaving out factors of retardation, Q (about) $= \times \sqrt{64 \times 2} = 5{,}500$ cubic feet per second; or, applying the necessary coefficients, about 5,000 cubic feet per second. The demand upon this reservoir, when the entire system is built at the headwaters of the Mississippi, will be not more than 3,600 cubic feet per second.

The tail-races of sluices to be of timber as well as the slucies themselves; the toe and front of the dam to be protected by low retaining walls, rip-rap, brush apron, &c., as delineated in the sketches herewith; the foundation to be, in general length of cross-section, at least 220 feet, and to be of grillage laid within an area bounded by two lines of sheet-piling (an intermediate line of sheet-piling and bulkhead also). The whole space for the foundation to be first coffer-dammed. All timber above low-water to be preserved either by the kyanizing or creosoting process, if within the limits of the appropriation to do so. No waste-way is provided for, as the great size of the sluices permit this appendage to be dispensed with here, as in high-water they will be capable of taking off the surplus water faster than it enters the reservoir.

It is proposed at this present writing to cut the necessary timber (or as much as may be accessible, the rest to be bought at the best rates possible), provided such can be done upon the Indian reservation without cost to the United States, or at reasonable rates for stumpage, if such be chargeable and legal and to collect bowlders, earth, &c., by day labor.

The general estimate for this work, as determined from the best information available, the force of men to be housed, subsisted, taken to and from the work either by teams or by marching, is given in the following table, approximately :

80 laborers, twelve months, at $30 per month	$28,800 00
5 carpenters, twelve months, at $40 per month	2,400 00
1 assistant engineer, 16 months, at $150 per month	2,400 00
1 overseer, sixteen months, at $125 per month	2,000 00
2 sub-overseers, twelve months, at $75 per month	1,800 00
1 steam engineer and sawyer, sixteen months, at $75 per month	1,200 00
1 cook, sixteen months, at $50 per month	800 00
3 assistant cooks, sixteen months, at $30 per month	1,440 00
Subsistence equal to 1,156 months of one man, at $12 per month	13,872 00
75-horse-power engine and boiler	2,500 00
12-inch pump	450 00
Spare pump, second-hand	150 00
Sawmill and fixtures	1,000 00
Iron work for pile-driver	250 00
Blacksmith's outfit	250 00
156,500 pounds iron, at 5 cents per pound	7,825 00
Tools	1,000 00
4 horses, at $150 each	600 00
4 yoke oxen, at $125 per yoke	500 00
Carts, wagons, harness, &c	500 00
Kitchen and dining-room furniture	500 00
200 barrels cement, at $5 per barrel	1,000 00
Total	71,237 00

The cost of nearly all the items is contained in the estimates for labor. For instance, especially, the cost of four flats, two to operate on Leech Lake and two upon Lake Winnibigoshish, is estimated at $500 apiece, or $2,000 probable cost of the four. The necessary birch-bark canoes will probably cost $50. The necessary houses for the men and sheds for animals, estimated at $1,000. Kitchen appliances and furniture at about $500. The other items are observable in the table above given. I would respectfully request, if this project be approved, authority to employ the necessary assistant engineer, overseer, suboverseers (master laborers), &c., and to hire the services of, or purchase and subsist, the draft animals enumerated in the above table and at rates of cost (pay) as approximately mentioned in the same, as well as authority to hire the day labor, procure the plant, &c., as above enumerated.

The site for dam is about 175 miles by river from Aitkin, on the Northern Pacific Railroad. In winter, when the ground and streams are frozen, teams and men can cross the country from Aitkin to the dam-site. In summer they must go by Leech Lake and the agency, portaging from Portage Lake to Lake Winnibigoshish. A small steamer on Leech Lake (no cabin) occasionally tows flats or fleets of canoes loaded with Indian supplies and hay. It may be necessary occasionally to hire this steamer; rates not known, but supposed to be reasonable. Authority is requested to cover such hire if found necessary.

Please see general and detail maps of this country, as well as plots of borings upon line of proposed dam forwarded with my report of January 15, 1879. Lands liable to overflow are given in lists forwarded April 12 last. Instruction as to procedure in occupation of reservation land, and use of material from same, is respectfully requested.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JOSEPH P. FRIZELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., June 30, 1880.

SIR: I have the honor to make the following report of a journey to the headwaters of the Mississippi, in compliance with your order of the 12th instant, for the purpose of making examinations and procuring information with reference to the construction of a dam at the outlet of Lake Winnibigoshish, as required by the recent act of Congress.

I left Saint Paul Tuesday morning, the 15th instant, in company with Mr. C. J. A. Morris and two attendants, being provided with tents and camp equipage. We proceeded to Brainerd, Minn., by rail, where we procured provisions for our journey, and a team to take us to Leech Lake, reaching the old agency and trading post on the evening of Thursday, the 17th. Here we procured two birch-bark canoes, and engaged four Indians to accompany us on the journey. I first proceeded down Leech Lake to the outlet, and examined the site of the dams proposed for converting that lake into a reservoir. Thence, crossing to the westerly side of the lake, we ascended a creek some 5 or 6 miles into Portage Lake, whence we carried our boats and luggage some 2 miles to Lake Winnibigoshish.

It being of primary importance to ascertain where stone can be procured for the construction of the dam, a couple of days were spent in this search. Understanding from the Indians that large quantities of bowlders occur on Cass Lake and the river above, we went up to Cass Lake and through the chain of lakes above, ascending the river to the first rapids. Large numbers of bowlders occur here and on the shore of Cass Lake, but no rock in place could be discovered.

Returning to Lake Winnibigoshish, we next examined the region between it and Bowstring Lake, it having been asserted by persons familiar with the locality that a 15-foot rise of Lake Winnibigoshish would throw the water over into Bowstring. We ran levels up the main stream coming in from the direction of Bowstring far enough to be assured that no trouble of this kind need be apprehended. We next visited the dam-site at the outlet of Lake Winnibigoshish, which appears to be well chosen. There is an abundance of Norway pine timber in this vicinity which will answer well for the submerged parts of the work. From this point we proceeded down the river examining the dam-sites at Mud Lake, Vermillion River, and Pokegama Falls. Below Grand Rapids I left the boats, and in company with Mr. Morris visited the southeasterly extremity of Pokegama Lake, where it has been reported that a moderate rise of the lake would cause it to overflow into the Mississippi. I am of opinion that some further examination will be necessary to settle that point. Continuing our journey down the river we reached Aitkin, a point on the Northern Pacific Railroad, on the afternoon of Sunday, June 27. The high stage of water obliterated all the rapids on this part of the river. The main impediments to navigation noticed were snags, large number of trees having recently fallen in from caving banks.

The amount of money disposable for the work (the Winnibigoshish dam) will not warrant us in undertaking an absolutely permanent structure. We should be obliged to adopt as cheap a mode of construction as is consistent with safety. A method involving the necessity of future renewals of parts of the work to save present expense. The work must consist mainly of timber and earth, these materials being most easily procurable; only a small quantity of cement masonry need be employed. A large quantity of rough stone is necessary for paving the up-stream slope of the embankment, which will be exposed to violent action of waves, and for protecting the bed of the channel at the outlet of the sluice. Large numbers of granite bowlders can be procured on the shores of Cass Lake. On the outlet of the lake, a number of miles below the dam-site, the bed is lined with bowlders of large size which could be grappled up and made use of. If these sources prove insufficient, an inexhaustible quantity can be procured on the shores of Leech Lake. It is probable that a sufficient quantity of split stone can be procured by splitting these bowlders with plug and feather.

I would offer these suggestions as to the commencement and prosecution of the work:

1. To settle claims for damages resulting from overflow of lands in accordance with the terms of the act of appropriation. These lands are understood to be wholly on the Indian reservation. They are hardly of any value except for the timber growing on them, which is chiefly Norway pine. Of this there are immense quantities and all merchantable. The right of flowage purchased of the Indians must include the right to cut the timber which would otherwise, of course, be destroyed. The amount realized from the timber ought, under judicious management, to pay all damages from flowage.

2. The road from Brainerd to Leech Lake Agency should be put in repair, as it must be our line of communication for passengers and ordinary supplies. It is mainly practicable for teams, but some 10 miles next Leech Lake is in bad order. Some bridges are gone and others are in unsafe condition. The expenditure of a few hundred dollars here would be judicious. A couple of stout barges to be moved by oars

should be built on Leech Lake, and the like on Winnibigoshish. The trail from Portage Lake to Winnibigoshish should be made practicable for teams and a few obstructions removed from the creek running from Portage to Leech Lake. This will give us a line of communication from Brainerd to the dam-site, and enable us to commence the work.

3. As soon as practicable a small steamboat should be placed on the river above Pokegama. There is now a steamer at Aitkin which it is presumed could be chartered to take freight up to Grand Rapids as often as a load could be got ready.

Very respectfully, your obedient servant,

JOS. P. FRIZELL,
Assistant Engineer.

Capt. CHARLES J. ALLEN,
Corps of Engineers.

W 10.

RESERVOIRS AT THE SOURCES OF THE MISSISSIPPI AND ITS TRIBUTARIES IN WISCONSIN AND MINNESOTA, INCLUDING ROCK RIVER IN WISCONSIN AND ILLINOIS—REPORT ON THE SURVEYS AND EXAMINATIONS OF THE SEASON OF 1880.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., January 16, 1881.

GENERAL: I have the honor to render the following report of the work of the past season, appertaining to the establishment of storage reservoirs at the sources of certain streams in Wisconsin and Minnesota, for the improvement of the navigation of those streams, and, ultimately, of the main Mississippi River.

The appropriations by act of Congress in 1878 and 1879 had reference to the sources of the Mississippi, Saint Croix, Chippewa, and Wisconsin rivers. The river and harbor act of Congress, approved June 14, 1880, section 2, refers only to the sources of the Mississippi River, including the Rock River, in Wisconsin and Illinois.

It seems necessary, then, on account of the wording of the different acts, to make this report in two parts.

PART I.—FOR RESERVOIRS AT SOURCES OF THE MISSISSIPPI, SAINT CROIX, CHIPPEWA, AND WISCONSIN RIVERS.

The small balance of funds on hand by early spring, 1880, only admitted of closing calculations, revision of areas of land liable to overflow, and forwarding the lists of the latter, as well as a study to the date of forwarding of proportions of rainfall actually feeding the lakes and water-courses; these were forwarded to the Chief of Engineers under dates of April 12, May 13, and June 12, 1880, and they are herewith referred to as part of this report. *They were marked as approximate, and can only be so considered.*

Meteorological observations were continued at Wausau, Wis.; and subsequently, upon the appointment of a surgeon at the trading-post on Leech Lake, renewed at the latter point. The greatest difficulty has been experienced in obtaining the services of competent observers in the district under examination. Appendix A gives the results of observations at Wausau, Leech Lake, Duluth, and Saint Paul.

Congress, by act approved June 14, 1880, appropriated the sum of $75,000 to be used in the construction of a dam (experimental) at the outlet of Lake Winnibigoshish, sources of the Mississippi River, "*Provided*, That all injuries occasioned to individuals by overflow of their lands shall be ascertained and determined by agreement or in accordance with the laws of Minnesota, and shall not exceed in the aggregate

five thousand dollars." The lands subject to overflow are all upon the Chippewa Indian Reservation, and are stated in the report of December 12, 1879, as nearly as could be ascertained.

Early in June last, preceding the promulgation of the act of Congress above referred to, and in anticipation of the same, a party was dispatched from this office to examine the country adjacent to the site of the proposed dam, in order to report at once upon facilities for putting the work under way at an early date. The party returned and made report. The matter, however, was referred to a Board of Engineers, who proposed doing the work by contract instead of by day labor, and who made some modifications in plan. This report was dated August 5, 1880, and together with drawings (the latter made as soon as possible) forwarded to the proper authorities. Before, however, any active proceedings could be taken under the act of Congress in the construction of this dam, the opinion of the honorable the Attorney-General was asked as to interpretation of the act, and the right of the United States officers to occupy the proposed site, to take timber, earth, and stone from the reservation, and to overflow certain lands upon the latter. It appeared to the United States engineers that the alleged prospective damage to the Indians by the overflow of lands, assembling of material, &c., that they would never use, consisted more in sentiment than in fact.

The honorable the Attorney-General rendered the opinion, under date of the 13th of August last, that *in effect* the act of Congress ordering the dam and authorizing the necessary consequences did not authorize the Indians to dispose of, or the United States to accept of, gratuitously or by purchase, the occupancy with all its perquisites; and that if such authority could be implied from the words of the act, no person had been authorized to treat with the Indians to meet the case. Accordingly no further steps were taken towards building the dam. The opinion of the honorable the Attorney-General is appended to this report and marked B. This dam will be referred to further on.

The reports of General G. K. Warren, April 30, 1870; Col. F. U. Farquhar, February 4, 1875; Col. F. U. Farquhar, January 23, 1878; Col. D. C. Houston, January 21, 1878; General G. K. Warren, Fox and Wisconsin rivers especially, page 104, February 11, 1876; Maj. C. J. Allen, January 15, 1879; Maj. C. J. Allen, December 12, 1879; Maj. C. J. Allen, January 15, 1880; Maj. C. J. Allen, December 23, 1880, should be carefully studied in connection with this report if errors arising from misconception as to value of and cost of reservoirs are to be avoided.

As will be shown further on, the sources of the Saint Croix, Chippewa, and Wisconsin rivers were ignored by the terms of section 2, river and harbor act, approved June 14, 1880, so that no borings, gaugings, or other observations could be made upon them the past season in order to supplement what was absolutely necessary from the work of 1878 and 1879.

Therefore, I have nothing of importance to add to the statements in regard to these sources to what appears in my report of January 15, 1880, excepting the belief that about 25 per cent. might safely be added to the estimates of first cost therein given.

PART II.—THE RESERVOIR SYSTEM ON THE HEADWATERS OF THE MISSISSIPPI RIVER, INCLUDING ROCK RIVER IN WISCONSIN AND ILLINOIS. (SEE SECTION 2, RIVER AND HARBOR ACT, APPROVED JUNE 14, 1880.)

The literal and legal construction of the pertaining paragraph in this act and section was that no money under such act could be applied to

surveys excepting at the headwaters of the Mississippi River and upon the Rock River in Wisconsin and Illinois.

SOURCES AND PORTION OF MAIN STREAM, ROCK RIVER.

A report, with map, was forwarded to the department under date of the 23d of December, 1880, so that it is unnecessary to refer to it further than to ask that it be appended to this report.

RESERVOIRS AT SOURCES OF THE MISSISSIPPI RIVER, SURVEYS, ESTIMATES, ETC.

Operations in the field were as follows: A party under the charge of Mr. W. S. Morton, assistant engineer, started early in August to make detailed and supplementary surveys (gaugings of streams and borings at dam sites included) for the proposed reservoirs at Gull Lake and Pine Rivers, both tributary to the Mississippi river above Brainerd, and a further examination of the country surrounding Lake Winnibigoshish, at the outlet of which it has been proposed to place an experimental dam; the examinations here were to ascertain more thoroughly than had been heretofore the danger of run-arounds (meaning waste into other lake systems) that might follow the construction of dams of 12, 14, and 16 feet lift above the low-water of 1878 and the extent and cost of diking necessary to prevent such waste. The elevation of Bowstring Lake, heretofore regarded as tributary to Lake Winnibigoshish, was also ascertained by actual lines of levels, and an additional line of levels was run in order to ascertain the elevation of the divide between Lake Winnibigoshish and Ball-Club Lake (please see large maps on file at the department). The results proved that Bowstring Lake was 30 feet in elevation above Winnibigoshish, and that its waters eventually reached Hudson's Bay; also, that there was no danger of flanking a dam with 16 feet lift by way of Ball-Club Lake. Bowstring Lake watershed being thus separated from the system, a reduction of supply would follow; but this is in large part nullified by areas of watershed above Pokegama Falls being added to the system after due ascertainment. The subreports of Assistants W. S. Morton and R. Davenport, herewith, are respectfully referred to. They are marked Appendixes C and D.

Another party, under the immediate charge of Mr. G. O. Foss, assistant engineer, started, on the 4th of October, to examine and survey the proposed dam-site at the Falls of Pokegama, in order to ascertain if the five proposed dams to be located at various points above and at Pokegama could not be replaced by one high dam at the latter point; the claim that such high dam would be both feasible and profitable having been so repeatedly made and urged by lumbermen and engineers as to render it necessary to settle the question at once. Mr. Foss's report, hereto appended, is marked E. Assistant Charles Wanzer, who was charged, in October last, with the general supervision of all the surveys under this office, those for the reservoirs included, reports the following as to the suggested high dam at Pokegama Falls:

The party under Mr. G. O. Foss, assistant engineer, to whom was delegated the surveys and examinations around Pokegama Falls to ascertain the practicability of one high dam at that point replacing the five dams previously recommended, was only able to make examinations in reference to the danger from run-arounds into the Mississippi River below the falls. There was not sufficient time to run flowage-lines which would accurately demonstrate the capacity of the proposed dam; and the figures showing capacity are based on former examinations and known elevations of the country, and are entirely within safe limits.

Mr. Foss finds that—

Eighteen thousand one hundred and ninety linear feet (nearly 3½ miles) of diking will have to be constructed, in addition to the dam proper, in order to retain the waters tributary to Pokegama Falls. These dikes are principally located on the east side of Pokegama, and on the west side of Horseshoe Lakes, and are rendered necessary on account of the swamps and creeks connecting these lakes with the Mississippi River. North of the falls the country is found to be free of depressions that can affect the capacity of the proposed reservoir.

The cost of the proposed dikes, made of earth embankment with a puddle wall extending to the underlying strata of clay, is estimated to be abont $700,000. This estimate is based on the supposition of finding clay foundations at an average depth of 10 feet below the surface of the ground. No borings have been made; and actual knowledge of the formation of the country may either reduce or increase this estimate materially.

The cost of the dam, designed to be built of earth embankment, on solid rock foundation, with slopes well protected by gravel and loose rock, and with cut masonry sluices and face walls, is estimated to be abont $400,000, or, in close figures, the entire cost of dikes and dam is estimated to be $1,161,798.28. The estimate for the dam is certainly none too high to cover all contingencies, unless it is found that the rock in place around the dam-site can be used for building purposes in construction. At the estimated cost, as given, it is calculated to procure the necessary granite for the sluices, &c., at Sauk Rapids. The estimates for the dikes can only be changed by a more accurate knowledge of the formation of the country.

The drainage area tributary to Pokegama Falls is now determined to be 3,432 square miles, or 95,678,668,800 square feet. This, after deducting the area of the reservoir, which will be 11,142,741,800 square feet, will leave as the total available watershed 84,535,927,000 square feet, which will furnish to the reservoir 59,175,148,900 cubic feet of water, on the basis of 0.7 foot of water being available for reservoir purposes over the entire drainage area. The holding capacity of this reservoir will be 71,019,935,280 cubic feet, which is an excess of 11,844,786,380 cubic feet over the above-computed supply. It will overflow Lake Winnibigoshish to a depth of about 3 feet.

It would seem that the prospective cost of this high dam would certainly condemn it, when compared with the far cheaper method of constructing the five smaller dams, and when to these estimates are added the damages to accrue by overflow of lands, which will embrace an area of between 400 and 500 square miles, the economy of the greater number of smaller dams will become more apparent. Something, too, might be said in reference to the constant danger to the whole upper country, arising from the impounding of such a vast quantity of water at any one place. Of course, everything that skill and foresight could accomplish would be done to render this dam and its attendant dikes perfectly safe; but leakages are likely to occur both from bad construction and from the burrowing of small animals (such as muskrats, otter, and mink) under the foundations. These little animals have frequently caused smaller dams to go out, by starting leaks, and they particularly infest the Upper Mississippi regions. The picture of a 30-foot wave with the backing of a 400-square-mile sheet of water breaking loose and starting towards the sea is not a pleasant one to contemplate, and its possibility should, I think, be avoided, unless immense advantages can be demonstrated to compensate for the risks incurred.

As Congress has already ordered the construction of the proposed dam at Lake Winnibigoshish, and as it is supposed that at least that dam will be built, it was considered advisable to make computations for a 24-foot dam at Pokegama Falls, which would flow just to the foot of the Lake Winnibigoshish dam. The results of these computations are as follows:

A flowage of 24 feet above the low-water of 1878 at Pokegama Falls will furnish a reservoir with a surface area of 83.7 square miles, equal to 2,333,426,400 square feet.

The holding capacity of the reservoir will be only 25,644,637,760 cubic feet. The 6 feet reduction in the height of the flowage decreases the capacity of the reservoir immensely, principally because the flowage line will be below both Lakes Winnibigoshish and Leech, and the holding ground over these two magnificent natural reservoirs will be entirely lost, thus at one blow taking away the surface area of these two lakes, which is nearly 274 square miles.

The drainage area above Pokegama Falls and below Lake Winnibigoshish is 1,998 square miles, equal to 55,701,043,200 square feet, which will leave, after subtracting the overflowed surface of the proposed reservoir, 53,367,615,800 square feet as certainly available for drainage purposes. This area, on the same basis of computation as has been used in prior cases in this report, will furnish an annual supply to the reservoir of 37,357,331,760 cubic feet, or a surplus annual supply over the capacity of the reservoir of 11,712,694,000 cubic feet. This surplus is certainly too large to be lost sight of (amounting to 1,506 cubic feet per second for a period of 90 days) and will require a supplemental reservoir to be constructed in order to retain it.

The construction of the 24-foot dam at Pokegama will require the building of 14,220 linear feet of diking to prevent run-arounds into the Mississippi River below the falls.

These dikes are estimated to cost	$422,585 86
The dam proper estimated to cost	317,114 02
Total cost of dam and dikes	739,699 88

In the above estimates only the actual cost of constructing the dam and dikes is considered; the damages to overflowed lands cannot be intelligently determined from the amount of information at present in this office.

The style of dam estimated above is the same as that estimated on for a 30-foot dam at the same place, viz, earth embankment, with 18 feet width of crest, slopes 2 to 1, with a puddle wall extending through the whole length, and down to clay or rock foundation; masonry sluices, and slopes well protected by gravel and loose rock.

To retain the surplus supply that would be furnished to this reservoir, a supplemental dam could be constructed at the outlet of Leech Lake which would easily accommodate the entire quantity of water which would be desired to be impounded. This reservoir, with a 4-foot height of dam above the low-water of 1874, would afford a holding capacity of 22,567,564,800 cubic feet, and would decrease the drainage area directly tributary to Pokegama Falls by 27,906,278,400 square feet, and have an annual supply to itself of 19,534,394,880 cubic feet, and would easily relieve the proposed 24-foot dam at Pokegama of its entire surplus supply.

This dam was estimated by Colonel Farquhar, Corps of Engineers, to cost $55,000, and this sum would of course have to be added to the estimated cost of the 24-foot dam at Pokegama in order to make a proper comparison of this proposed system with the original proposition of the five smaller dams.

I see no reason why this proposition of a 24-foot dam at Pokegama Falls should not be condemned on the same grounds as the 30-foot dam at the same place, viz, its excessive cost, with no compensating engineering points in its favor.

The views of Mr. Wanzer meet my full concurrence, with the exception of the factor representing the available rainfall or the amount that actually finds its way into the water-courses, a factor that he takes to be one-third of the annual precipitation, while my belief is that one-fourth the annual precipitation can be impounded in the reservoirs between the 20th of October and the 1st of July following, years of unusual drought excepted.

To return to the surveys at Gull Lake, Pine River, and Winnibigoshish.

A suitable location for a dam was found half a mile below the outlet of Gull Lake, nearly at the position selected for such by Major Farquhar in 1875. Borings were made at the dam-site, the plottings of which accompany this report. The borings extended to about 32 feet to 44 feet below the flowage line resulting from the height of the proposed dam, and show alternations of yellow sand, sand with small amount of clay, quicksand, coarse sand, and fine gravel, &c., terminating in blue clay. at depths of from 26 to 39 feet below flowage, or 17 feet to 30 feet below the surface of low-water.

The drainage area of the Gull Lake River is 235.97 square miles, or 6,578,466,048 square feet. If we assume this as the watershed and multiply the area by one-fourth the rainfall (assumed at 25 inches per annum), the product being taken as the amount that can be impounded between the 20th of October and the 1st of July following, we have $6,578,466,048 \times 0.52 = 3,420,802,344$ cubic feet supply. Now, diminishing the area of watershed by the area of the entire reservoir, and using the same factor of rainfall, we have $5,549,864,602 \times 0.52 = 2,885.929,593$ cubic feet supply to be drawn upon after July 1. And this is the calculation for a dam with 9-foot lift above low-water, affording, for 100 days, a discharge per second of 334 cubic feet. The low-water discharge of Gull River, as measured last season, is about 128 cubic feet per second. The width of the stream is about 200 feet; there is no navigation upon it; some logs are run down. It is doubtful if loggers will use the stream for more

than 60 days within an entire year; so that, supposing we deal with the stream as only requiring a water-supply of 400 cubic feet per second, for 60 days, for running logs, and that for 30 days prior to July 1 this quantity of water be required, we see that as a result a quantity to be subtracted from the storage from October 20 to July 1 following of about 60 cubic feet per second might be required. This supposition would reduce the discharge from the proposed 9-foot reservoir, after July 1, to 274 cubic feet per second for 100 days to add to the low-water volume of the stream. The capacity of reservoir for a dam of 9-foot lift is about 3,884,905,220 cubic feet, leaving an excess of capacity over supply of 998,975,627 cubic feet.

But the character of the country admits of the erection of a dam of 12½ feet lift by the building of two dikes in addition to the dam proper. This dam would flow Gull Lake to the depth of 12 feet above the plane of low-water and furnish a holding capacity of 10,385,075,643 cubic feet. Upon the supposition that but one-fourth of the annual precipitation could be impounded before July 1, and as certain wants of loggers must be met before that time each year, it would take over three years' supply to fill the reservoir resulting from the last-named dam. But it would seem better to build the large dam in order to store up a full supply of water during seasons of navigation when the surface of the river remains at a reasonable stage; the water could be drawn from the reservoir created by this dam, as from a 9-foot dam.

The estimated cost of a 9-foot dam is placed at	$47,870 33
The estimated cost of a 12½-foot dam is placed at	63,147 87

The dikes proposed by Assistant Morton can be dispensed with by changing the location of the main road from Brainerd to Leech Lake for some 7 miles, making the total cost, for

9-foot dam	$48,585 83
12½-foot dam	63,857 37

The tabulated list of lands to be overflowed by the erection of the 12½-foot dam is forwarded herewith, and marked Appendix F.* It is only an approximation, and the estimate of cost is not included in the cost of dams. Probably the sum of $1,000 should be added to cover claims for damages that may arise in changing the location of the Leech Lake road.

The most suitable location for a dam-site in the Pine River system was found upon Pine River, one-fourth of a mile below Cross Lake. The country on either side of the dam-site attains a general elevation of from 20 to 25 feet above Cross Lake; but examination demonstrated that a dam of 17½ feet lift is the highest that can be built with security from overflow and run-arounds. Borings for foundations were made, and the results are shown on the accompanying plotting. Hard-pan was found at from 10 to 15 feet below low-water. The holding ground of this reservoir consists mainly of 21 lakes.

The drainage area of the Pine River Basin, after deducting the area of the reservoir when filled, can be taken at 503.64 square miles, or 14,040,677,376 square feet. Assuming that the annual precipitation of this basin is 25 inches (although the average annual precipitation is, doubtless, greater for a decade), we will have, for the supply to this reservoir, impounded between October 20 and the 1st of July following, taking it that one-fourth of the annual precipitation will be available for impoundment between those dates, 7,301,152,235 cubic feet. The capac-

*Omited. Printed in Sen. Ex. Doc. No. 48, Forty-sixth Congress, third session.

ity of the reservoir being 7,474,384,104 cubic feet, no surplus supply of consequence will obtain upon the basis of these estimates. The low-water flow of Pine River, as measured, was found to be about 150 cubic feet per second. As in the case of Gull River, probably about 400 cubic feet of water per second may be required for 60 days for running logs down the stream.

This want might call for, from the storage, from October 20 to July 1, about 50 cubic feet per second from the supply between October 20 and July 1. Deducting this quantity per second, we would be able to discharge for 100 days after July 1 about 780 cubic feet per second to add to the normal low-water discharge.

Should it be found that more than one-fourth of the rainfall be available for feeding the water-courses, the supply might exceed the capacity, in which case the surplus would equal, or approach, the quantity of water necessary for running logs before opening the dams. Three supplemental reservoirs, at Norway Lake, South Fork of Pine River, and at Mountain Lake, have been suggested by Assistants Wanzer and Morton, to retain the surplus in the case supposed, the cost of the three to be about $44,000. But, from present data, it is thought that they can be omitted. The cost of the main Pine River dam, including the necessary amount of diking, sluices, &c., is placed at $80,158.09.

Lists of lands liable to overflow, and marked Appendix G*, are appended, and are only considered as approximate. Cost of land damages not considered in estimating the cost of dams.

The estimates for the Pine River and Gull Lake reservoirs are considerably in excess of those rendered by Major Farquhar in 1875. They are made upon a basis of much later information, and are designed to remain, if built, for years.

The field work around Lake Winnibigoshish was mainly confined to surveys of the southern and eastern sides of the lake. Lines of level were run both east and west from the dam-site, and the number of linear feet of diking required to prevent flanking the dam at the outlet of Lake Winnibigoshish, of heights, respectively, 12 feet, 14 feet, and 16 feet above low-water of 1878, estimated.

The Board of Engineers, convened in Saint Paul August 3 last, decided upon a dam at the outlet of the lake to have a waste-way 14 feet above the plane of low-water; this practically leaves the reservoir area of the lake as given in my report of January 15, 1879, viz, 4,312,701,360 square feet.

The cost of the necessary diking, as given by Assistant Morton, for such lift, is $23,580. The cost of the dam as estimated, in accordance with the plans of the Board of Engineers, is $85,597, or the total cost of dam and dikes, as nearly as can be estimated in the absence of precedent in that wilderness, is placed at $109,177. The estimated cost of the dam, given in the report of my predecessor in 1875, was $59,969.80. I subsequently raised this for an experimental dam to $70,000; next, to $80,000. A cheap experimental dam might be built for $50,000 (in fact, $40,000 was one estimate tendered), but such would be temporary, and liable to overthrow (or blowing out, as loggers term it), and would not be creditable as a piece of engineering. All of these estimates for the Winnibigoshish dam have been based upon the supposition that if land damages be paid to the reservation Indians, or they be propitiated in some way not as yet provided for as known to this office, timber and other material could be taken from the portion of the reservation to be flowed over and paid for, as well as from portions not so situated. Land

*Omitted. Printed in Sen. Ex. Doc. No. 48, Forty-sixth Congress, third session.

damage is here, as well as at other dam-sites discussed in this and other reports upon reservoirs, problematical as to money value.

The area (corrected) of watershed tributary to the proposed dam at the efflux from Lake Winnibigoshish is 39,977,625,600 square feet; and the product of this, by 0.52 foot assumed as available rainfall, would afford, for the supply to be drawn off after July 1, to add to the low-water volume, 20,788,365,312 cubic feet, leaving a surplus capacity of reservoir over supply for one year of about 24,000,000,000 cubic feet, thus enabling nearly two years' entire precipitation to accumulate within this reservoir when it happens, as is sometimes the case, that the stage of water in the navigable river does not require an increment.

It becomes necessary now to revert to the estimated supply of water to the reservoirs, as given in my reports of January 15, 1879, and December 12, 1879.

In the former report was the following table, mostly made up from the report of 1875:

Locality.	Height above reduced stage of 1874.	Length of dam.	Area of basin.	Area of reservoir.	Capacity of reservoir.	Supply in cubic feet.	
						1st method.	2d method
	Feet.	*Feet.*	*Square feet.*	*Square feet.*	*Cubic feet.*		
Winnibigoshish ..	14	1, 114	52, 745, 932, 800	4, 312, 701, 360	45, 754, 204, 380	36, 923, 152, 960	37, 773, 739, 008
Leech Lake	4	3, 000	27, 906, 278, 400	6, 091, 430, 400	22, 567, 564, 800	19, 534, 394, 880	15, 460, 977, 021
Mud Lake.....	6	1, 000	4, 460, 544, 000	480, 902, 400	2, 885, 414, 400	3, 122, 380, 800	3, 137, 885, 040
Vermillion	10	2, 300	12, 071, 346, 800	961, 804, 800	5, 770, 828, 800	8, 449, 942, 760	8, 562, 762, 188
Pokegama	7	400	4, 990, 223, 600	658, 209, 024	3, 751, 791, 436	3, 493, 156, 520	5, 117, 636, 396
Total.....	.....	.....	102,174,325,600	12, 505, 047, 984	80, 729, 803, 816	71, 522, 027, 920	70, 052, 999, 653
Add to this from dams at—							
Gull Lake.....	12	450	7, 582, 924, 800	724, 868, 400	6, 133, 548, 000	5, 265, 920, 000	.....
Pine River.....	12	600	15, 360, 998, 400	.....	4, 913, 000, 000	10, 667, 353, 750	.....

The cost of the dams at the sources of the Mississippi, as estimated in 1875, being placed at, from all reports, $336,458.60.

In my report of December 12, 1879, I stated (see page 6, Executive Document No. 39, House of Representatives, Forty-sixth Congress, second session) 55,795,903,840 cubic feet as an *underestimate* of the quantity to be impounded and ready for use by July 1, equivalent to an increment of 6,400 cubic feet per second for 100 days after the 1st of July. We took the normal low-water discharge past Saint Paul at 5,800 cubic feet per second; the sum of the two, then, would be 12,200 cubic feet assured, past Saint Paul, for 100 days, when low-water and difficult navigation ensue.

If, instead of requiring the use of the reservoirs for 100 days, we only required them to be drawn upon in full for 50 days, we could assure for the 50 days (believing all our calculations to be correct) 18,600 cubic feet per second, and so on for other demands.

The cost of all the dams I increased to $386,927.39, exclusive of the cost of telegraph lines, maintenance of works, attendance, &c. Aside from the revised estimates of cost of the Gull Lake and Pine River dams, and the Winnibigoshish dam, already given, I should add 25 per cent. to the cost of the other dams in the system. The aggregate will appear in the recapitulation of estimates.

Referring to the quantity taken as the low-water discharge (5,800 cubic feet per second), past Saint Paul, subsequent to July 1, my reports, prior to this, have always contained that figure on account of its being safe.

Quite thorough and tedious calculations, though only claimed as approximate in results, have been made in this office, of the quantity of water flowing per second, for 1875, past Brainerd, Sauk Rapids, Fridley's Bar, and Saint Paul; also, for the latter place for 1879. The average discharges per second at Saint Paul for a few months have been selected; they are:

	Cubic feet per second.
For July, 1875	26,609
For August, 1875	16,231
For September, 1875	33,157
For October, 1875	18,794

Available rainfall for year over entire basin—that of the Minnesota River included—tributary to the Mississippi River at Saint Paul, 9.3 inches.

At Saint Paul, 1879, discharge, average:

	Cubic feet per second.
July, 1879	32,983
October, 1879	7,040

The above figures show that the figure 5,800 assumed as representing the average low-water discharge past Saint Paul for the months of July, August, September, and October, is really very low, and one that has been taken as on the side of safety.

Very few cases can occur when it will be necessary to draw upon the reservoirs for 100 days to their full capacity; they can frequently accumulate, and this is one reason for erecting as large storage reservoirs as the ground affords.

The results gathered from the investigation of Appendix H (the computations by Mr. J. P. Frizell) show that in 1875 the available rainfall for the year upon the following-named basins was:

	Inches.
Brainerd Basin	10.5
Sauk Rapids Basin	9.57
Fridley's Bar Basin*	9.16

The tables of rainfall for 1875 show—

	Inches.
At Saint Paul	30.66 precipitation.
At Fort Snelling	27.12 precipitation.
At Fort Ripley	28.17 precipitation.
At Duluth	25.13 precipitation.

**Statement showing rainfall, rainfall collected, and percentage of rainfall collected, in inches, at Cochituate reservoir. From report of Boston water board.*

Year.	Rainfall.	Rainfall collected.	Percentage of rainfall collected.	Year.	Rainfall.	Rainfall collected.	Percentage of rainfall collected.
	Inches.	*Inches.*			*Inches.*	*Inches.*	
1852	47.93	20.61	43	1867	56.25	20.25	36
1853	55.73	19.51	35	1868	49.71	24.86	50
1854	43.15	22.87	53	1869	64.34	23.16	36
1855	54.96	.....	.....	1870	55 89	26.27	47
1856	40.80	.....	.....	1871	45.39	14.98	33
1857	63.10	46.69	74	1872	48.47	16.96	35
1858	48.66	19.46	40	1873	45.43	27.26	60
1859	49.02	38.24	78	1874	35.93	19.40	54
1860	55.44	19.40	35	1875	45.49	17.74	39
1861	45.44	25.45	56	1876	48.49	19.40	40
1862	49.69	22.36	45	1877	43.80	23.21	53
1863	69.30	27.03	39	1878	53.58	26.25	49
1864	42.60	17.04	40	1879	38.01	17.86	47
1865	49.46	21.27	43				
1866	62.32	15.58	25	Averages	49.59	22.81	45.6

The basins above Pokegama Falls, and above the dam-sites at Gull Lake and Pine rivers, are essentially the same as over the entire Brainerd Basin, so that the factor representing the available rainfall may apply to each. The drainage area of the Brainerd Basin is 1,183 square miles; of the Pokegama, Pine River, and Gull Lake basins, 4,162 square miles, or about four-sevenths of the area of the Brainerd Basin. Taking the flow past Brainerd from about the middle of November to July 1, throwing out the 25 days preceding the middle of November, we have, as due from Pokegama Falls, Gull Lake, and Pine River, about 7,500 cubic feet per second for 100 days' use; or 15,000 cubic feet per second for 50 days' use. Let any practical steamboatman answer as to what can be done with an assured navigation for 50 days when the river is ordinarily low.

It would certainly seem a very safe estimate to take one-fourth the annual precipitation over the 4,162 square miles net area of watershed, tributary to the river at Pokegama Falls, and to the Gull Lake and Pine River reservoirs, as the quantity to be impounded prior to July 1. Taking the *least* recorded average of rainfall, viz, 25 inches, we have, using one-fourth as factor, $\frac{4162 \times \overline{5280}^2 \times 0.521}{100 \times 86{,}400}$ = quantity per second for 100 days; Q = 6,923 cubic feet per second. Now, accepting the latter as the safer estimate, we can still obtain the 6,400 cubic feet per second, to add to the 5,800 cubic feet assumed (though altogether too low) average low-water discharge for 100 days from July 1, by withdrawing 523 cubic feet per second for 100 days, which, stored and used for 40 days prior to June 1 for logging and navigation, the date of opening the latter, though set at May 1, not obtaining by any means upon the river above Brainerd, have, to feed the stretch, above Brainerd, prior to opening the reservoirs, 1,307 cubic feet per second, and to this, which would occur just at the foot of the falls, must be added the contributions of the watershed from the falls to Brainerd, minus, of course, those of the Pokegama, Gull Lake and Pine River basins.

I see as yet no reason for changing unfavorably to the reservoirs the figures rendered in my reports of December 12, 1879, and January 15, 1880, excepting as to cost, an increase of which, within ordinary limits, would be but a "bagatelle," provided they prove of the value to the main Mississippi River below Saint Paul that has been accorded them. The main question as to advisability seems to hinge upon their effect as auxiliaries to works of contraction upon the main Mississippi below Saint Paul, a stretch of river not under my jurisdiction in any way.

The many questions that have been raised by professionals as to loss by evaporation, absorption, wants of vegetation, capilarity, effect of cultivation, denudation and reforesting of wooded districts, dip of strata towards or from streams, &c., have all been presented, and most of them answered by me in former reports. As to cultivation of soil following or not deforesting of countries, probably no one of observation denies that thoroughly plowed soil with furrows at right or acute angles, and even with furrows parallel to the direction of flow of surface water, retains much of the first drainage following rains. If much of this water settles through the ground so as to reach a hard-pan, it will filter into or from the stream according to the dip of strata and according to elevations of certain points of the strata above the beds of the streams. Borings might determine much towards answering all these questions, provided money and, especially, four or five decades of time were available.

Two main questions bearing on minor ones seem to have been asked by reviewers, self-constituted or appointed:

1. Can it be answered categorically whether or not the exact proportion of rainfall that actually feeds the water-courses (all items of loss left out) has been ascertained by daily or hourly gaugings at the outlet of a basin for a season of years.

2. Is there any precedent for the construction on so large a scale of reservoirs to aid navigation?

Answer to each—No. Experiments upon hydraulics, models for architecture, fortifications, guns, &c., have generally been made upon a limited scale. For successful working of reservoirs reference is made to the construction and operation of those assisting to maintain the great hydraulic works at Lowell, Mass.

As to daily or hourly gaugings for a year or several years at the outlets of several typical basins so as to compare the annual flow with the product obtained by multiplying the drainage area of such basin by the recorded precipitation for one year (or several years), the necessity of such has been fully recognized in my previous reports and strongly urged.

But as the case has been, we found it best to take at the outset the first step, viz, to find places to store water, their capacities, &c. Then simultaneously, if possible, to find how much water could be placed in them and what such quantity of water would accomplish. The second step, upon which we have *already entered*, consists in obtaining the ratios of flow to rainfall, and borings and digging of wells, to satisfy the geological querist. The third step to consist in construction and operation of dams dependent upon full facts rendered, conclusions arrived at, appropriations by Congress, &c.

In order to meet questions that will certainly arise, it seems best to continue the observations by stationing a gauging party at the outlet of a defined basin at each of the Upper Mississippi, Saint Croix, Chippewa, and Wisconsin River headwaters, and to establish meteorological stations at each; the time to cover not less than a year; observations to be made daily, and, if possible, hourly. Also to make borings at all projected dam-sites; to better report upon the resources of the country; to work up past and future records, maps, drawings, estimates, &c. For one season's operations, as thus delineated, not less than $47,000 will be required.

RECAPITULATION OF ESTIMATES.

In this I include the system for the headwaters of the Mississippi, Saint Croix, Chippewa, and Wisconsin rivers. I will consider, first, the sources of the Mississippi.

The report of 1875 gave as the cost of the dams necessary—

At Winnibigoshish	$59,969 80
At Leech Lake	55,000 00
At Mud Lake	31,737 00
Below Vermillion River	56,245 20
At Pokegama Falls	75,334 00
At Pine River	32,386 20
At Gull Lake	25,786 20

At the time of making these estimates the officer in charge had not the means now at hand for estimating with anything like accuracy. For the proposed dams at Lake Winnibigoshish, at Gull Lake, and at Pine River, the estimates, as concluded upon from the past season's surveys, have already been stated. As to the others, I would, judging from the past season's work upon the sources of the Mississippi River, add 40 per

cent. to the estimates already given, supposing, of course, that the United States Government desires first-class and permanent work. The sum total of the seven proposed dams at the sources of the Mississippi will then be $558,135.08, and, if telegraph lines be necessary, $573,660.08.

The cost of the system of dams upon the Saint Croix, Chippewa, and Wisconsin rivers, noted in my report of January 15, 1880, was placed at $988,338.80. To this estimate I would add, in the light of recent examinations upon the sources of the Mississippi River, 25 per cent., bringing the estimate up to $1,335,423.50.

The total first cost, then, of the entire system for the Mississippi, Saint Croix, Chippewa, and Wisconsin rivers is estimated at $1,809,083.50. This is exclusive of land damages—a problematical sum.

I would especially call attention to the valuable report of Mr. Charles Wanzer, assistant engineer, marked Appendix I, herewith, it being well worthy of perusal.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX A.

Monthly mean rainfall at Wausau, Wis., and at Leech Lake, Duluth, and at Saint Paul, Minn.

1879, FOR ELEVEN MONTHS.

Locality.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Wausau	2.12	0.64	1.05	3.58	2.17	3.92	5.06	2.97	1.55	4.41	3.51	30.98
Leech Lake	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Duluth	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Saint Paul	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

1880, FOR ONE YEAR.

Locality.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Wausau	1.88	0.65	1.70	3.10	2.65	14.23	6.24	2.91	1.98	1.42	0.80	1.05	38.61
Leech Lake	.....	.....	.....	.....	.....	.....	.....	.....	1.31	2.39	0.97	1.39	6.06
Duluth	1.21	1.57	2.43	3.17	4.31	10.40	1.98	4.35	1.86	2.32	2.89	1.62	38.11
Saint Paul	0.81	0.97	2.30	1.58	2.63	5.55	2.75	3.63	1.74	2.18	2.93	2.69	29.76

APPENDIX B.

OPINION OF THE ATTORNEY-GENERAL OF THE UNITED STATES, RELATIVE TO LAND TO BE OVERFLOWED, ETC., IN THE CHIPPEWA INDIAN RESERVATION, BY CONSTRUCTION OF RESERVOIR AT LAKE WINNIBIGOSHISH.

DEPARTMENT OF JUSTICE,
Washington, D. C., August 13, 1880.

SIR: Referring to the clause of the river and harbor improvement bill, approved une 14, 1880, which appropriates "for the reservoirs at the headwaters of the Mis-

sissippi River, to be used in the construction of a dam at Lake Winnibigoshish, seventy-five thousand dollars: *Provided*, That all injuries occasioned to individuals by overflow of their lands shall be ascertained and determined by agreement, or in accordance with the laws of Minnesota, and shall not exceed in the aggregate five thousand dollars." Yours of the 22d of July states that an actual survey ascertains that all of the land to be overflowed will be within the limits of the reservation secured to the Chippewa Indians by treaty February 22, 1855, and thereupon you submit for my consideration the following questions:

"1. Can the United States, in its own right, appropriate such of the lands as will be overflowed? and if not—

"2. Would the right, if acquired, to cut the timber on the lands to be overflowed within the limits of the reservation, to be paid for in the same way as other materials, and the right to overflow the land in perpetuum, to be paid for out of the $5,000 provided for injuries, &c., satisfy the requirements of the act?

"3. What person or persons are authorized to treat with the War Department or its agents for the transfer of the land in question?"

First. The Indians usually have only the right to occupy their lands, while the complete ultimate title and the exclusive right of acquiring possession is held by the national government, independently of the will of the Indian tribes. (Johnson *vs.* McIntosh, 8 Wheat., 603; Cherokee Nation *vs.* Georgia, 5 Pet., 17.)

Whether the Chippewas in Minnesota have only this general right, or whether under the treaty aforesaid, they have a more valuable title to these lands, in either case the United States unquestionably has the *power*, and Congress must judge of the emergency in which it is rightfully exercised, to take any lands owned or occupied by Indians, as well as those of white or other citizens.

The real question in the present case, as it seems to me, is whether or not Congress, by the above-quoted language of the act of June 14, 1880, has evinced an intention to exercise this right of eminent domain or of supreme sovereignty as to lands lying within the Chippewa Indian Reservation.

As to the lands of private or individual owners, outside the reservation, this purpose is made sufficiently apparent by the proviso. The terms of this proviso, however, cannot be extended so as to embrace these Chippewa *tribal* lands, because expressly confined to the lands of individuals, and because there would be no propriety in following the laws of Minnesota relating to the sale or appropriation of property as to this peculiarly situated territory of exclusively Federal jurisdiction.

It may be further observed, that while the proviso limits the amount to be paid as compensation for injuries by overflow to the lands of individuals to $5,000, the communication of the Engineer-in-Chief, to which you invite my attention, states that the damage to the Chippewa lands by such overflow will exceed the whole sum appropriated for the construction of the dam. This tends to show that there was no design to take these lands by overflow, making just compensation.

It is probable that Congress intended to take them *without* awarding any compensation, or providing any means by which its proper measure should be ascertained? To me this seems very improbable. I cannot think Congress would make it a condition precedent to entering upon this work, or to expending this appropriation upon it, that the injuries occasioned to individuals, as definitely ascertained, should not exceed $5,000, and yet leave the Chippewa damages indefinite, unlimited, without any method of present or future appraisement. Nor can I believe that Congress designed to take them without ever making compensation therefor; such a course would not be in accordance with that heretofore uniformly pursued in dealing with the Indians, nor at all consonant with the plainest principles of justice. True, the Indians ordinarily have no title to the soil in fee, though they do sometimes acquire it by contract with the United States; but the Supreme Court of the United States has twice within the last ten years declared "the right of the Indians to their occupancy is as sacred as that of the United States to the fee." (United States *vs.* Cook, 19 Wall., 593, top; Beecher *vs.* Wetherby, 95 U. S., 526, top.)

In delivering the opinion in this last-cited case, Field, J., observes "that occupancy could only be interfered with, or determined, by the United States. It is to be presumed that in this matter the United States would be governed by such considerations of justice as would control a Christian people in their treatment of an ignorant and dependent race" (95 U. S., 525).

From a clause simply appropriating a specific sum to construct a dam, we cannot, properly, infer a purpose to dispossess the Indians without any provision for their compensation. They have not been so dealt with heretofore. In the opinion of Marshall, C. J., in the case of the Cherokee Nation *vs.* Georgia, *ubi sup.*, it is observed that "the Indians are acknowledged to have an unquestionable and heretofore unquestioned right to the lands they occupy until that right shall be extinguished by a *voluntary* cession to our government" (5 Pet., 17). There has been no such extinguishment of their right to the lands to be flowed by the erection of the dam in question.

Out of the lands ceded by these Indians to the United States by treaty of February

22, 1855 (10 Stats., 1165, Art. I), the land in question was expressly reserved by the second article (10 Stats., 1166, Art. II). Prior to the approval of the act of March 3, 1871, chap. 120, sec. 1 (16 Stats., 566), such voluntary cessions to extinguish the Indian title have been made by means of treaties for reasons indicated in the decisions of the Supreme Court in the before-cited and many other cases. This act of March 3, 1871, is now found in Revised Statutes, "Section 2079. No Indian nation or tribe within the territory of the United States shall be acknowledged or recognized as an independent nation, tribe, or power, with whom the United States may contract by treaty; but no obligation of any treaty lawfully made and ratified with any such Indian nation or tribe prior to March third, eighteen hundred and seventy-one, shall be hereby invalidated or impaired."

This act, then, did not affect the rights of these Chippewas. Since its passage, when it has become desirable to extinguish the Indians' right of occupany, Congress has, by preliminary enactments, authorized agreements, conditional upon its approval, to be made with the Indians, and subsequently ratified them if satisfied with their terms. One example of this course will be cited. The act of June 20, 1878, chap. 359 (20 Stats., 232), authorized a commission to arrange with the Utes for their removal in Colorado; the act approved June 15, 1880, accepts and ratifies the agreement thus made.

In view of the whole history of our dealings with the Indians, early and recent, of their anomalous and dependent situation, unable to sue in the Federal courts (5 Pet., 17), and not amenable to the laws and courts of any State for acts done upon their respective reservations, I cannot deduce a purpose upon the part of Congress to effect a total change of policy and to invalidate the treaty securing to these Chippewas the peaceful occupancy of the lands in question, as an inference—and by no means an obvious or necessary one, but rather the contrary—from the language of a single clause of a voluminous appropriation act allowing a given sum to be expended in the erection of a reservoir dam at a designated point.

While, then, I think the United States has the power, in the construction of this dam, to take by overflow necessary lands and to appropriate materials thereon for its erection, I also think that Congress has not, in the legislation submitted to my examination, exercised this power so far as the Chippewa Indian Reservation is concerned, and that there is no authority given to overflow any part of this reservation or to take timber or materials therefrom. If this is a fatal hinderance to the prosecution of the improvement, further Congressional action must be invoked.

Second. In reply to your second question—though the conclusion above stated may preclude the necessity of any reply—I would say that the Indians do not own the timber, have no right to cut it themselves, except for the sole purpose of improving the land, and cannot sell it to anybody else. This is expressly determined in United States *vs.* Cook (19 Wall., 591). Having only the right to occupy the land, timbered or other, they should only be compensated for the injury done to this occupation, and not for the value of the timber, &c. But Congress has not provided for the cutting of this timber any more than for the overflow of the soil. Taking land by overflowing it is an exercise of the right of eminent domain. (Pumpelly *vs.* Green Bay Company, 13 Wall., 166.) The act of June 14, 1880, not giving the authority to the officers of the United States so to take land within the Indian reservation, cannot be held to have conferred upon the Indians a power to sell it, or make any agreement about it, which they did not before possess.

Third. The foregoing observations give this answer to your third inquiry: that there is no person authorized to treat, either on the part of the United States or of the Indians, for the transfer of the lands in question.

The papers which accompanied your letter are herewith returned.

Very respectfully,

CHAS. DEVENS,
Attorney-General.

Hon. ALEXANDER RAMSEY, *Secretary of War.*

APPENDIX C.

SURVEYS AND EXAMINATIONS ON THE UPPER MISSISSIPPI RIVER FOR PROPOSED RESERVOIRS.

REPORT OF MR. W. S. MORTON, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 15, 1880.

SIR: I have the honor to submit the following report of examinations and surveys of Gull Lake and Pine River reservoirs, and the completion of the survey of Lake

Winnibigoshish reservoir, made under your direction from August 10 to October 28, 1880.

The system of lakes drained by Gull Lake River, and the lake system of which Pine River forms the effluent, were examined and surveyed with reference to their practicability as storage reservoirs; their holding capacity, the location, cost, and extent of dams necessary to impound their water supply, the resultant damages to lands and property; and the general features of the country in which they are situated. Subsequently, Lake Winnibigoshish reservoir was surveyed with the view of ascertaining the exact height to which a dam at its outlet could be built without danger of overflow to its reservoir banks; and, also, the amount, if any, of diking that would be necessary as auxiliary to dams respectively 12, 14, and 16 feet in height above low water.

Gull Lake system, the first examined, was found to possess all requisite conditions for reservoir purposes. The holding-ground will be largely confined to lakes, twenty-five in number, which precludes any great increase in the evaporation area. The banks of the lakes are, in general, high. Comparatively few swamps were found, while the valuable lands (timber lands) are almost entirely above flowage. The general character of the soil is a fine sand, varying in depth from 4 to 15 feet.

The timber over a large portion of the reservoir is almost worthless, largely consisting of "jack" pine, which has but little market value. Norway and white pine are also found and constitute the most valuable possessions of the country; the land, in general, being unfit for agricultural purposes. Some hay meadows will be subject to overflow, and these, in connection with three farms and their improvements, comprise a large percentage of the damage.

A table of land damages for both Gull Lake and Pine River reservoirs is appended.

The pine timber is found almost exclusively on lands from 15 to 50 feet above the lakes. The greater part of that near the lake shores and easy of access has been cut, while a large amount yet remains that lies some distance back from the water. Norway pine predominates, although last year, of 14,000,000 feet, board-measure, taken out through Gull Lake River, about one-half was white pine.

The initiatory work done on the reservoir consisted in the selection of a dam-site and the establishment of the height of the dam.

A suitable location was found half a mile below Gull Lake, on Gull Lake River, which differs but little in position and extent from that reported upon by Maj. F. U. Farquhar, in 1875. Two borings were make on the dam-site, and a third, 400 feet above it, in the river bottom. The results of the several borings are given in the following tables, which borings, from subsequent examinations, I would judge to give a fair representation of the general character of the soil throughout the reservoir.

Borings at Gull Lake dam-site.

First boring.		Second boring.		Third boring.	
Depth in feet.	Material.	Depth in feet.	Material.	Depth in feet.	Material.
0 to 4.3	Fine sand.	0 to 1.0	Black soil.	0 to 4.5	Black surface soil and peat.
4.3 to 8.0	Yellow sand and clay.	1.0 to 3.0	Sand and small stones.	4.5 to 8.7	Gray sand and water.
8.0 to 12.0	Yellow sand and clay; 15 per cent. of blue clay.	3.0 to 4.0	Water and large rocks, with a thin layer of blue clay at bottom.	8.7 to 10.4	Quicksand.
12.0 to 13.6	Brown sand with some clay.	4.0 to 4.7	Yellow sand and part clay.	10.4 to 11.1	Gravel and blue clay.
13.6 to 16.0	Gray sand and clay.	4.7 to 19.5	Quicksand.	11.1 to 12.0	Coarse gray sand and small stones.
16.0 to 21.6	Gray quicksand.	19.5 to 24.3	Coarse sand mixed with fine gravel.	12.0 to 25.1	Quicksand.
21.6 to 22.0	Small gravel with gray sand.	24.3 to 27.6	Yellow sand.	25.1 to 27.8	Coarse yellow sand with gravel and small stones.
22.0 to 27.5	Quicksand.	27.6 to 29.0	Fine gravel and sand; 15 per cent. of sand.	27.8 to 29.4	Coarse yellow sand.
27.5 to 28.5	Sand and gravel.	29.0 to 32.0	Blue clay with but little sand.	29.4 to 31.0	Bluish sand and clay.
28.5 to 30.0	Blue clay with a little sand.			31.0 to 32.0	Blue clay.
30.0 to 32.0	Blue clay, 95 per cent.; sand, 5 per cent.				

Clay, for dam construction and lying but a few feet below the surface, was found within a short distance of the dam-site in sufficient quantity for the necessary puddle-wall foundation. Rock can be obtained on the shores of Gull Lake, 4 miles from the dam-site, with water transportation the entire distance. Beach Gravel can also be obtained from Gull Lake, 1 mile from the proposed work. Norway pine for the wooden portion of the dam can be procured in the immediate vicinity.

The drainage area of Gull Lake River is 235.97 square miles. Assuming 25 inches as the mean annual rainfall of this region, and that seven-tenths feet of the rainfall is discharged by the river, we have a yearly supply to the reservoir of 4,604,926,233 cubic feet, equal to a mean discharge of 146.02 cubic feet per second. Still further reducing this amount by taking from the drainage area the area of the reservoir surface, to allow for the increased evaporation surface, we have 3,884,905,220 cubic feet as the available discharge. This amount, as reduced from the drainage area, is very closely checked by the gauging of Gull Lake River. In the subsequently designated flowage lines, the heights given refer to the low-water surface of Gull Lake as a datum plane.

There is a fall of half a foot from the lake to the dam-site. To hold this supply, a dam 9 feet in height will be necessary, which will give a flowage of 8½ feet on Gull Lake.

The character of the country will admit of a 12-foot flowage, and a survey for a reservoir with a 12½-foot dam was made.

With this flowage, 10,385,075,643 cubic feet can be stored. Two dikes will be necessary as adjuncts to thls latter dam to prevent overflow to the reservoir banks. I would recommend the construction of a 12½-foot dam at this point as a work more in accordance with wise economy, as the beneficial results would be increased two and a half times by the 3.5 feet additional height at less than one-third additional cost. It would double the supply to the Mississippi River in seasons of extreme low-water, which occurs every two or three years. A little over two and a half years, with an annual rainfall of 25 inches, would be required to fill the reservoir.

The following tables give the respective cost of 9 and 12½-foot dams. These estimates are carefully made and with due reference to the location of the work as regards material, labor, and accessibility.

GULL LAKE.

Nine-foot dam.

Embankment, gravel, 440 cubic yards, at $1.50 per cubic yard	$660 00
Embankment, rock, 660 cubic yards, at $1.75 per cubic yard	1,155 00
Earthwork, including puddle wall	23,206 50
Sheet piling, pine, 117,600 feet, B. M., at $14 per M	1,646 40
Cross-ties, 2,640 linear feet, at 5 cents per foot	132 00
Driving sheet piling	980 00
	27,779 90

Length of dam, 350 feet.

Sluices.

Timber, 83,521 feet, B. M., at $14 per M	$1,169 30
Three gates, at $250 each	750 00
Labor and iron on timber, at $6 per M	501 13
	2,420 43

Pool crib and sluice foundations.

Piling, 3,700 linear feet, at 15 cents per foot	$555 00
Timber, 172,022 feet, B. M., at $14 per M	2,408 31
Labor and iron on timber	1,032 13
Brush for protection	278 00
Rock for protection	486 50
Rock for filling cribs, 1,100 cubic yards, at $2	2,200 00
	6,959 94

Log-sluice, and crib for sluice.

Timber, 146,264 feet, B. M., at $14 per M	$2,047 70
Piling, 1,152 linear feet, at 15 cents per foot	172 80
Rock for crib, 484 cubic yards, at $1.75 per yard	847 00
Labor and iron on timber, at $6	877 58
	3,945 08

Coffer-dam.

Timber, pine, 58,320 feet, B. M., at $14 per M	$816 48
Excavation, 1,070 cubic yards, at 50 cents per cubic yard	535 00
Embankment, earth, 3,129 cubic yards, at $1.50 per cubic yard	4,693 50
Driving sheet piling	720 00
	6,764 98

RECAPITULATION.

Total cost of Gull Lake dam	$27,779 90
Total cost of sluices	2,420 43
Total cost of pool and crib	6,959 94
Total cost of log-sluice	3,945 08
Total cost of coffer-dam	6,764 98
Total cost of road embankment	6,333 90
	54,204 23

Estimate of the cost of Gull Lake Dam, for 12-foot flowage.

Puddle wall, clay, 8,631 cubic yards, at $2 per cubic yard	$17,262 00
Excavation for dam, 3,882 cubic yards, at 40 cents per cubic yard	1,552 80
Excavation for puddle wall, 9,042 cubic yards, at 60 cents per cubic yard	5,425 20
Excavation for pool foundations, 5,444 cubic yards, at 30 cents per cubic yard	1,633 40
Embankment for dam, 12,756 cubic yards, at 50 cents per cubic yard	6,378 00
Gravel for slope wall, 612 cubic yards, at $1.50 per cubic yard	918 00
Rock for paving, 918 cubic yards, at $1.75 per cubic yard	1,606 50
Sheet piling, pine, 144,000 feet, B. M., at $14 per M	2,016 00
Cross-ties, pine, 3,600 linear feet, at 5 cents per foot	180 00
Cost of driving sheet piling	1,200 00
	38,171 90

Length of dam, 400 feet.

Sluices.

Pine timber, 133,584 feet, B. M., at $14 per M	$1,870 17
Labor and iron on timber, at $6 per M	801 50
Four sluice-gates, at $250 each	1,000 00
	3,671 67

Pool crib-work.

Lumber, pine, 188,056 feet, B. M., at $14 per M	$2,632 78
Rock for crib filling, 1,194 cubic yards, at $1.75 per cubic yard	2,089 50
Rock for brush, 278 cubic yards, at $1.75 per cubic yard	486 50
Piling, pine, 4,240 linear feet, at 15 cents per foot	636 00
Brush	278 00
Labor and iron on lumber, at $6 per M	1,128 34
	7,251 12

Total cost of log-sluice, $4,065.08; total cost of coffer-dam, $6,764.98.

RECAPITULATION.

Cost of dam	$38,171 90
Cost of coffer-dam	6,764 98
Cost of log-sluice	4,065 08
Cost of pool and cribs	7,251 12
Cost of sluices	3,671 67
Cost of superintendence	1,000 00
	60,924 75

NOTE.—This estimate includes the cost of an extra crib outside of pool cribs, the log-sluice discharging into the river proper.

Dike No. 1, for 12-foot flowage.

Embankment, earth, 89.6 cubic yards, at 50 cents per cubic yard	$44 80
Embankment, gravel, 120 cubic yards, at $1 per cubic yard	120 00
	164 80

Length of dike, 160 feet; average height, 2.0 feet.

Dike No. 2, for 12-foot flowage.

Embankment, earth, 1,821 cubic yards, at 50 cents per cubic yard	$910 50
Embankment, gravel, 134 cubic yards, at $1 per cubic yard	134 00
Embankment, rock, 225 cubic yards, at $1.50 per cubic yard	337 50
Excavation, 1,175 cubic yards, at 30 cents per cubic yard	352 50
Sheet piling, pine, 16,680 feet, B. M., at $19 per M	317 82
	2,052 32

Length of dike, 190 feet; average height, 6 feet.

A reservoir with a 9-foot dam will give a discharge of 499.6 cubic feet per second for a low-water period of ninety days. A 12½-foot dam will create a reservoir capable of furnishing every second year a discharge of 993.9 cubic feet for the same length of time, with a surplus capacity of 2,656,324,510 cubic feet for the years when the supply exceeds that which would be given by a mean rain-fall.

The dam-site is but 12 miles from Brainerd, Minn., the lumbermen's headquarters for this section of country. Laborers, supplies, and the necessary outfit for dam construction can be obtained at this point. Sawed lumber (sheet piling, &c.) can be purchased at Chase's Mills, 7 miles below the dam-site, at the crossing of Gull Lake River by the Northern Pacific Railroad.

A gauging of Gull Lake River, one-quarter of a mile below Gull Lake, was made with very satisfactory results.

The river at the time of gauging was near a mean stage. The results show a discharge of 128 cubic feet per second, the river being one-half foot above low-water. The extreme range of the river is about 2 feet. It was anticipated that the supply to the reservoir would fall short of its holding capacity, and, with this belief in view, Pelican Lake was examined with reference to utilizing its drainage area. The elevation of the lake was found to be 16 feet above Gull Lake. The lake has no outlet nor inlets. Its natural drainage is through Pelican Brook into Pine River.

A rise of 4 feet would give it an outlet in this direction. The lake has a surface area of 13.7 square miles, and a total drainage area of 31.39 square miles. Its supply, allowing seven-tenths of a foot as the available amount of rain-fall, would be 612,572,083 cubic feet.

The country surrounding the lake was examined with reference to a cut from the lake to the Gull Lake watershed, and a feasible location cross-sectioned. The total length of the cut that would be necessary is 870 feet, at a cost of $1,268. The water supply to the lake is evidently evaporated from its surface, with the exception of the amount that may percolate through into Pelican Brook. The supply that would be furnished to Gull Lake by the proposed cut would be inappreciable.

The main road from Brainerd to Leech Lake Indian Agency passes through the reservoir, and in two places will need embankment to bring it above flowage. The longer and more expensive of the two will be necessary at the crossing of the creek connecting Round and Gull lakes near "Gray's Ranch." The second embankment will be required one-quarter of a mile above "Roy's Ranch." The lengths and average heights of the embankments, their cost, and the cost of three wooden bridges that will be necessary, one at "Gray's Ranch," and the other two at Fish Trap and Cullen creeks, are given below.

Road embankment, for 8½-foot flowage, at Gray's Ranch.

Embankment, earth, 7,181 cubic yards, at 40 cents per cubic yard	$2,872 40
Riprap, rock, 800 cubic yards, at $1.50 per cubic yard	1,200 00
Cost of new road	105 00
	4,177 40

Road embankment, for 8½-foot flowage, one-quarter mile above Roy's Ranch.

Embankment, earth, 1,200 cubic yards, at 40 cents per cubic yard	$480 00
Riprap, rock, 220 cubic yards, at $1.50 per cubic yard	330 00
Three wooden bridges, each 48 feet long, at $365.50 each	1,096 50
Superintendence for both embankments	250 00
	2,156 50

Road embankment, at Gray's for 12-foot flowage.

Embankment, earth, 13,774 cubic yards, at 40 cents per cubic yard	$5,509 60
Embankment, rock, 1,628 cubic yards, at $1.50 per cubic yard	2,442 00
Three wooden bridges, each 48 feet long, at $365.50	1,096 50
	9,048 10

Length of embankment, 1,530 feet; average height, 8.4 feet.

Road embankment, one-quarter mile above Roy's, for 12-foot flowage.

Embankment, earth, 3,273.5 cubic yards, at 40 cents per cubic yard	$1,309 40
Embankment, rock, 436 cubic yards, at $1.50 per cubic yard	644 00
Superintendence for both embankments	300 00
	2,253 40

Length of embankment, 630 feet; average height 8.4 feet.

Total cost of embankments	$11,301 50
Cost of new road	105 00
	11,406 50

At all other points where the road runs below flowage a change in its location can be made. Seven miles of new road will be necessary, at a cost of $15 per mile, or $105.

The location of the road through the reservoir can be entirely changed, which would much reduce the total cost of the improvement. A good road, now existing, extends from Brainerd to Pine River, below Cross Lake. The portion of this road from Brainerd to the end of Long Lake can be utilized. From this latter point, at a comparatively small cost, a new road can be cut through to the present Leech Lake road. The new road necessary to effect this junction will have a length of 7 miles, at a cost of $50 per mile, or $350. This would eliminate the cost of the change of road at Gull Lake, the estimated embankment, and two of the three new bridges, the bridge over Cullen Creek still being necessary.

The changed location of the road is shown on the accompanying tracing.

The method of survey adopted was as follows:

The location of the dam being first determined, a rough estimate was made of its required height to hold the water supply tributary to the reservoir. The large lakes were triangulated, the intermediate points being obtained with the stadia.

Cross-sections with the levels were run back from located points above flowage, by means of which the flowage lines and intermediate contours were established. The elevations of all the lakes were carefully determined, as were also the elevations and extent of the different swamps encountered. The topography of the country, as well as the character of the soil and timber, was noted, while the character of the lands liable to overflow was observed as far as possible. In some cases stakes were placed at the flowage line to mark the boundary of the damaged lands. Twenty-six days were consumed in the survey of this reservoir.

Total cost of dam for 9 feet rise, with road embankment	$54,204 23
Total cost of dam for 9 feet rise, without road embankment	48,585 83
Total cost of dam for 12½ feet rise, without road embankment	63,857 37
Total cost of dam for 12½ feet rise, with road embankment	74,548 37

These estimates include the cost of bridges and changing the location of the present road. One thousand dollars should be added to the estimated cost of the reservoir without road embankments, for damages that may be claimed by the farmers living near Gull Lake, on account of the changed location of the Leech Lake road.

Operations on Pine River reservoir were commenced September 9, the initiatory work, as at Gull Lake, consisting in the selection and location of a suitable dam-site.

The most favorable situation was found on Pine River, one-quarter mile below Cross Lake. The country on either side of the dam-site has a general elevation of from 20 to 25 feet above Cross Lake.

Careful instrumental examinations of this section resulted in the adoption of a dam 17.5 feet in height, the greatest available height compatible with perfect security from run-arounds. This dam will raise the surface of Cross Lake 16 feet above low-water. Building material, with the exception of clay, can be obtained within easy reach of the dam-site. The nearest deposit of clay, as far as known, lies 4 miles distant.

The foundations will rest on a stratum of "hard-pan" (coarse sand, gravel, and small pebbles, cemented together with clay), impervious to water. The borings given in the table below illustrate the general character of the country over a greater part of the reservoir.

In the tables following are also given the dimensions, amount of material, and cost of the proposed dam.

Borings at Pine River dam-site.

First boring.		Second boring.		Third boring.	
Depth in feet.	Material.	Depth in feet.	Material.	Depth in feet.	Material.
0 to 5.0	Yellow sand, with a few stones.	0 to 2.6	Gray sand, with small rocks; sand, 30 per cent.	0 to 2.0	Yellow and brown sand.
5.0 to 9.6	Fine gray sand and small stones.	2.6 to 7.4	Large rocks and stones in yellow sand.	2.0 to 3.0	Brown sand.
9.6 to 10.5	Coarse brown sand.			3.0 to 4.8	Gray sand and water.
10.5 to 12.4	Gray sand.			4.8 to 6.3	Blue sand and part clay.
12.4 to 13.2	Small gravel.	7.4 to 13.0	Coarse gray sand.	6.3 to 7.5	Fine brown sand.
13.2 to 16.3	Blue clay, with little sand.	13.0 to 17.0	Gray sand, with hard-pan and small stones.	7.5 to 10.6	Coarse brown sand and small stones.
16.3 to 22.0	Hard-pan, impervious to water.	17.0 to 21.0	Hard-pan, impervious to water.	10.6 to 14.0	Coarse gray sand and small stones.
				14.0 to 15.8	Fine hard gray sand.
				15.8 to 25.0	Gray sand and hard-pan, impervious to water.

Pine River Dam, for 16-foot flowage.

Puddle walls, clay, 10,334 cubic yards, at $2 per cubic yard	$20,668 00
Excavation for wall, 9,982 cubic yards, at 60 cents per cubic yard	5,989 20
Excavation for dam, 5,056 cubic yards, at 40 cents per cubic yard	2,022 40
Embankment for dam, earth, 20,329 cubic yards, at 50 cents per cubic yard	10,164 50
Excavation for pool, 5,953 cubic yards, at 30 cents per cubic yard	1,785 90
Gravel slopes, gravel, 1,071 cubic yards, at $1.50 per cubic yard	1,607 00
Rock paving, rock, 1,607 cubic yards, at $1.75 per cubic yard	2,812 25
Sheet piling, pine, 163,200 feet, B. M., at $14 per M	2,284 80
Cross-ties, 6,000 linear feet, at 5 cents per foot	300 00
Longitudinal timbers, 30,000 feet, B. M., at $14 per M	420 00
Driving piling, 27,200 linear feet, at 5 cents per foot	1,360 00
	49,414 05

Coffer-dam.

Timber, 58,320 feet, B. M., at $14 per M	$816 48
Excavation, 1,070 cubic yards, at 50 cents per yard	535 00
Embankment, 3,129 cubic yards, at $1.50 per yard	4,693 00
Driving sheet-piling	720 00
	6,764 98

Pool crib and sluice foundations.

Timber, pine, 211,305 feet, B. M., at $14 per M	$2,958 27
Rock for cribs, rock, 1,254 cubic yards, at $1.75 per yard	2,194 50
Brush for protection, brush	278 00
Rock for protection, rock	556 00
Piling, 5,312 linear feet, at 15 cents per foot	796 80
Labor and iron on timber, at $6 per M	1,267 83
Superintendence	2,000 00
	10,051 40

Sluices.

Timber, 224,485 feet, B. M., at $14 per M	$3,142 79
Six sluice-gates, at $250 each	1,500 00
Labor and iron on timber, at $6 per M	1,346 91
Driving sheet-piling, at 5 cents per foot	424 20
	6,413 00

Log-sluice.

Timber, pine, 160,890 feet, B. M., at $14 per M	$2,252 46
Piling, 1,440 linear feet, at 25 cents per linear foot	360 00
Rock for crib, rock, 484 cubic yards, at $1.75 per yard	847 00
Labor and iron on timber, at $6 per M	965 34
	4,424 80

RECAPITULATION.

Total cost of dam	$49,414 05
Total cost of pool and crib foundations	10,051 40
Total cost of sluices	6,413 90
Total cost of log-sluices	4,424 80
Total cost of coffer-dam	6,764 98
	77,069 13

Pine River Dike, for 16-foot flowage.

Embankment, earth, 3,287 cubic yards, at 50 cents per cubic yard	$1,643 50
Embankment, gravel, 180 cubic yards, at $1 per cubic yard	180 00
Embankment, rock, 275 cubic yards, at $1.50 per cubic yard	412 50
Excavation, 1,400 cubic yards, at 30 cents per cubic yard	420 00
Sheet-piling, 21,648 feet, B. M., at $20 per M	432 96
	3,088 96

Length of dike, 200 feet; average height, 9 feet.

The surface soil over the high ground of the reservoir is almost exclusively sandy loam, with underlying beds of gravel and, in places, bowlders. Broken Norway

ridges, interspersed with swamps and lakes, constitute the characteristic features of the country. No timber of any value will be flooded. The greater part of the best timber, white and Norway pine, has been cut, while the little that remains is found on land above flowage. The soil is, with but few exceptions, unfit for cultivation. Extensive hay meadows, lying in the vicinity of Hay Lake, are the most valuable lands that will be flowed, and, should all the lands subject to overflow be appraised at their present value, would constitute a large percentage of the total cost for damages.

Pine River reservoir consists of twenty-one lakes, the two largest of which, Upper and Lower White Fish, form over one-half the holding capacity. The evaporation area will not be largely increased, as the holding ground will be, mainly, confined to the lakes mentioned.

The drainage area tributary to the reservoir is 527.17 square miles. Taking from this area 23.53 square miles, the area of the reservoir when filled, and multiplying the result by seven-tenths of a foot, we have 9,828,474,163 cubic feet for the supply. The capacity of the reservoir for a 17½-foot dam is 7,474,384,104 cubic feet, which leaves a surplus supply of 2,354,090,059 cubic feet. This surplus can be held by three smaller reservoirs on Pine River, above White Fish Lake.

A dam 150 feet long, to raise the water surface 7 feet, could be placed on the South Fork of Pine River, at the crossing of the Leech Lake Road, that would create a reservoir with a storage capacity of 905,000,000 cubic feet. Another reservoir could be constructed to impound a part of the remaining surplus on Twenty-four-mile Creek, at the outlet of Mountain Lake. This would require a dam 100 feet long and 6 feet high, and would give a holding capacity of 625,000,000 cubic feet. A third reservoir could be established on the North Fork of Pine River, at the outlet of Norway Lake, that would store 511,830,000 cubic feet. This would require a dam 200 feet long and 7 feet high. The three reservoirs give a total storage capacity of 2,041,830,000 cubic feet. Taking the combined areas of the three reservoirs from the amount of surplus supply, to allow for the increased evaporation surface, we have 2,017,529,779 cubic feet for the amount to be held by the above dams. These figures, for the storage capacity of the auxiliary reservoirs, although approximate, are believed to be estimated within safe limits. The cost of the three dams are, approximately, as follows:

Dam on South Fork	$16,000 00
Dam at Norway Lake	18,000 00
Dam at Mountain Lake	10,000 00
	44,000 00

Adding to these the cost of the Cross Lake dam and dike, we have $124,158.09 for the total cost of the Pine River reservoirs.

It was thought that a dam could be built at the outlet of White Fish Lake that would give an increased height to Upper and Lower White Fish above the dam at Cross Lake sufficient to hold the surplus water, but the examinations instituted for this purpose disclosed its impracticability. The dam would need be 700 feet in length, while nearly a mile of diking would be necessary as auxiliary to it.

Pine River was gauged at a point one-half mile below Cross Lake. The results show a discharge of 154.2 cubic feet per second. The river at the time of gauging, from all indications, was at a stage three-tenths foot above low-water. The maximum range of the river is about 3 feet. The method of survey followed was in all respects similar to that used at Gull Lake.

From the uncertainty of the amount of work required at Lake Winnibigoshish it was decided to divide the party then at work on Pine River reservoir. This was done on the 17th of September, Mr. H. N. Elmer, my first assistant, being left with a triangulation and level party to complete the Pine River survey. Mr. Elmer deserves great credit for the intelligent, thorough, and rapid manner in which his allotted task was performed.

The problem presented for solution at Winnibigoshish Lake, as before stated, consisted in ascertaining the greatest height to which a dam could be built at the outlet of the lake without danger of overflow into other water systems, and also the amount, if any, of diking that would be necessary for dams respectively 12, 14, and 16 feet in height.

Active operations on this work were commenced on the 23d of September. The location of doubtful points in the reservoir could be ascertained to some extent from the section plots, and the work was in a measure laid out accordingly. The southern, eastern, southeastern, and northeastern portions of the lake required thorough and detailed examinations; the slope of the northern and western sides being well defined by streams. Commencing at the portage trail leading from Winnibigoshish to Leech Lake, continuous level lines were run east and west in directions in general parallel to the shore line of the lake, following the highest ground. Winnibigoshish Lake is bordered along its south and southeastern sides by swamp land extending from one-



R.30 R.29 R.28 R.27

T.139 T.138 T.137 T.136 T.135 T.134 T.133

LINE of DRAINAGE AREA of PINE RIVER RESERVOIR

LINE of DRAINAGE AREA between GULL LAKE and PINE RIVER RESERVOIR

LINE of DRAINAGE AREA GULL LAKE RESERVOIR

DRAINAGE AREA of PINE RIVER RESERVOIR = 527.175 Sq miles
1/3 RAIN FALL SUPPLY from " " WATERSHED = 9.828.474.163 Cu. Ft.
CAPACITY of " " RESERVOIR = 7.474.384.104 " "
" " SOUTH FORK " = 905.000.000 " "
" " NORTH " = 625.000.000 " "
" " MOUNTAIN PINE LAKE R = 511.830.000 " "
TOTAL " " The four PINE RIVER R. = 9.516.214.104 " "
1/3 RAIN FALL SUPPLY from PINE RIVER WATERSHED = 7.301.152.230 " "

AREA of GULL LAKE WATERSHED = 235.97 Sq miles
CAPACITY of RESERVOIR for 12½ ft DAM = 10.385.073.643 Cu Ft.
1/3 RAIN FALL = SUPPLY from WATERSHED = 3.864.905.220
1/4 " " = 2.898.928.592

MOUNTAIN PINE LAKE
DAM SITE (1320.3)
LAKE ADA
HAND LAKE
MITCHELL LAKE
FOX BROOK
LEECH LAKE ROAD
NORTH BRANCH PINE R.
NORWAY LAKE
DAM SITE
SOUTH FORK PINE R.
PINE RIVER RANCH
DAM SITE (1171.1)
PINE RIVER
TROUTLAKE
OTTER
CAMP LAKE
HAY LAKE
RUSH LAKE
WHITE FISH LAKE (1221.1)
BEAR
MOOSE
PIGS
HAY LAKE No 2 (1222.3)
HAY LAKE (1228.3)
CROSS LAKE (1218.0)
DAM SITE
POKEGAMA ROAD
GOULDS
O'BRIEN LAKE
PINE LAKE
GEER LAKE
PINE RIVER
NORTH BRANCH GULL RIVER
BRANDY BROOK
PELICAN LAKE (1208.4)
CULLENS (1139)
PROPOSED ROAD
RICE LAKE (1193.5)
LAKE EDWARD
LAKE HUBERT (1195.6)
MUD LAKE
GULL LAKE (1191.2)
GRAYS
ROUND LAKE (1191.9)
ROYS
LONG LAKE (1196.1)
DAM SITE (1198.6)
SOUTH BRANCH GULL RIVER
POKEGAMA ROAD
MISSISSIPPI RIVER
RED SAND LAKE (1198.9)
SYLVAN LAKE (1188.2)
(1184)
GULL LAKE RIVER
BRAINERD
CROW WING ROAD
NORTHERN PACIFIC R.R.
CROW WING RIVER

Map showing location of Proposed Reservoirs on Gull Lake and Pine River tributaries to the Mississippi River

From surveys made during 1880 under direction of Captain Chas J. Allen Corps of Eng'rs U.S.A.

Note.
Figures in brackets denote elevations above sea level.
Dotted lines denote flowage.

To accompany report of Capt. Chas J. Allen
Jan. 16th 1881.

quarter to 2½ miles back. The level lines were carried along the ridges forming the southern boundaries of these swamps, the west level line being extended until the Mississippi River between Cass and Winnibigoshish lakes was reached, and the east line until high ground contiguous to the dam-site was found. The elevation of Bowstring Lake, 3 miles northeast of Winnibigoshish Lake, was also obtained. The portion of the Mississippi River connecting Cass and Winnibigoshish lakes was thoroughly explored; also, the southern and eastern shores of the former lake.

The results of the examinations and surveys disclosed the following existing facts and conditions: low-water of Winnibigoshish Lake is the assumed datum to which all elevations of the surrounding country are referred, the elevation of the river at the dam-site being one-half foot below this datum.

Four dikes were found to be necessary for a 16-foot flowage; three dikes for a 14-foot; and two dikes for a 12-foot flowage. The dikes will all be situated at the south and southeast sides of the lake.

The general elevations of the high ground bounding Winnibigoshish Lake is from 20 to 35, and in some cases 70 feet above low-water. In a few places the dividing ridge of high ground is but from 400 to 600 feet in width, but of sufficient height to insure safety. The elevation of the divide between the Mississippi River above Winnibigoshish and Leech lakes watershed varies between 20 and 50 feet. The banks of Cass Lake are from 15 to 50 feet high.

Bowstring Lake, whose waters eventually find their way into Hudson's Bay, is 30 feet above the assumed datum. This elevation of the lake necessarily insures security from any overflow into it.

A portion of the country lying between Winnibigoshish and Bowstring lakes was designed for examination, and for this purpose a small working party was left behind after the operations of the main party had ceased. The severe and unprecedentedly early snow-storm of October 16 and 17 rendered it impossible to complete the designated work, and from the want of preparation for such unusual weather the party was compelled to return. The point to be reached was a divide between two streams, one flowing into Lake Winnibigoshish and the other into Ball-Club Lake, the divide being in a large swamp that extends from Bowstring to the latter lake. An elevation in this swamp, 12 feet above the assumed datum, was, however, obtained. The point reached by the levels was 2 miles from the divide. The swamp has a total fall of 42 feet in 9 miles, or 4.6 feet to the mile. This would make the divide 21.2 feet above the assumed datum, or 5.2 feet above flowage. From our observations and also from those of our predecessors in this region, I am of the opinion that no danger need be apprehended from this quarter for a 16-foot dam.

Should actual construction be commenced, two days' exploration with a level would give the elevation of this divide. All other doubtful points on the reservoir were examined instrumentally, and, with the construction of the dikes mentioned, a 12, 14, or 16 foot dam can be built with absolute security from overflow. Ten feet is the greatest height to which the low-water surface of the lake could be raised without diking.

Below will be found tables of the cost, dimensions, and amount of material estimated with reference to a 12, 14, and 16 foot flowage.

LAKE WINNIBIGOSHISH.

Dike No. 1, *for* 16-*foot flowage.*

Embankment, earth, 134 cubic yards, at 50 cents per yard	$67 00
Embankment, gravel, 22 cubic yards, at $1.50 per yard	33 00
	100 00

Total length of dike, 170 feet; maximum height, 1.8 feet.

Dike No. 2 (*Sec. No.* 1), *for* 16-*foot flowage.*

Embankment, earth, 7,318 cubic yards, at 50 cents per cubic yard	$3,659 00
Embankment, gravel, 475 cubic yards, at $1.50 per cubic yard	712 50
Embankment, rock, 712 cubic yards, at $2.25 per cubic yard	1,602 00
Excavation, 2,711 cubic yards, at 30 cents per cubic yard	813 30
Sheet piling, pine, 43,428 feet, B. M., at $20 per M	868 56
	7,655 36

Total length of dike, 1,130 feet; maximum height, 12.2 feet.

Dike No. 2 (Sec. No. 1), for 14-foot flowaye.

Embankment, earth, 4,966 cubic yards, at 50 cents per cubic yard	$2,483 00
Embankment, gravel, 332 cubic yards, at $1.50 per cubic yard	498 00
Embankment, rock, 500 cubic yards, at $2.25 per cubic yard	1,125 00
Excavation, 2,054 cubic yards, at 30 cents per cubic yard	616 20
Sheet piling, pine, 33,264 feet, B. M., at $20 per M	665 28
	5,387 48

Total length of dike, 625 feet; maximum height, 11.2 feet.

Dike No. 2 (Sec No. 1), for 12-foot flowage.

Embankment, earth, 2,050 cubic yards, at 50 cents per cubic yard	$1,025 00
Embankment, gravel, 187 cubic yards, at $1.50 per cubic yard	280 50
Embankment, rock, 281 cubic yards, at $2.25 per cubic yard	632 25
Excavation, 911 cubic yards, at 30 cents per cubic yard	273 30
	2,211 05

Total length of dike, 460 feet; maximum height, 8.2 feet.

Dike No. 2 (Sec. No. 2), for 16-foot flowage.

Embankment, earth, 4,767 cubic yards, at 50 cents per cubic yard	$2,383 50
Embankment, gravel, 357 cubic yards, at $1.50 per cubic yard	535 50
Embankment, rock, 460 cubic yards, at $2.25 per cubic yard	1,035 00
Excavation, 1,311 cubic yards, at 30 cents per cubic yard	393 30
Sheet piling, pine, 18,876 feet, B. M., at $20 per M	377 52
	4,724 82

Total length of dike, 610 feet; maximum height, 12.2 feet.

Dike No. 2 (Sec. No. 2), for 14-foot flowage.

Embankment, earth, 2,440 cubic yards, at 50 cents per cubic yard	$1,220 00
Embankment, gravel, 204 cubic yards, at $1.50 per cubic yard	306 00
Embankment, rock, 312 cubic yards, at $2.25 per cubic yard	702 00
Excavation, 872 cubic yards, at 30 cents per cubic yard	261 60
Sheet piling, pine, 8,580 feet, B. M., at $20 per M	171 60
	2,661 20

Total length of dike, 565 feet; maximum height, 10.2 feet.

Dike No. 2 (Sec. No. 2), for 12-foot flowage.

Embankment, earth, 971 cubic yards, at 50 cents per cubic yard	$485 50
Embankment, gravel, 81 cubic yards, at $1.50 per cubic yard	121 50
Embankment, rock, 125 cubic yards, at $2.25 per cubic yard	281 25
Excavation, 366 cubic yards, at 30 cents per cubic yard	109 80
	998 05

Total length of dike, 255 feet; maximum height, 8.2 feet.

Dike No. 3, for 16-foot flowage.

Embankment, earth, 14,132 cubic yards, at 50 cents per cubic yard	$7,066 00
Embankment, gravel, 832 cubic yards, at $1.50 per cubic yard	1,248 00
Embankment, rock, 1,248 cubic yards, at $2.25 per cubic yard	2,808 00
Excavation, 5,600 cubic yards, at 30 cents per cubic yard	1,680 00
Sheet piling, pine, 72,468 feet, B. M., at $20 per M	1,449 36
	14,251 36

Total length of dike, 1,000 feet; maximum height, 15.2 feet.

Dike No. 3, for 14-foot flowage.

Embankment, earth, 10,550 cubic yards, at 50 cents per cubic yard	$5,275	00
Embankment, gravel, 670 cubic yards, at $1.50 per cubic yard	1,005	00
Embankment, rock, 1,005 cubic yards, at $2.25 per cubic yard	2,261	25
Excavation, 3,881 cubic yards, at 30 cents per cubic yard	1,164	30
Sheet piling, pine, 39,204 feet, B. M., at $20 per M	784	08
	10,489	63

Total length of dike, 885 feet; maximum height, 13.2 feet.

Dike No. 3, for 12-foot flowage.

Embankment, earth, 5,418 cubic yards, at 50 cents per cubic yard	$2,709	00
Embankment, gravel, 391 cubic yards, at $1.50 per cubic yard	586	50
Embankment, rock, 587 cubic yards, at $2.25 per cubic yard	1,320	75
Excavation, 1,877 cubic yards, at 30 cents per cubic yard	563	10
Sheet piling, pine, 21,120 feet, B. M., at $20 per M	422	40
	5,601	75

Total length of dike, 855 feet; maximum height, 11.2 feet.

Dike No. 4, for 16-foot flowage.

Embankment, earth, 6,315 cubic yards, at 50 cents per cubic yard	$3,157	50
Embankment, gravel, 388 cubic yards, at $1.50 per cubic yard	582	00
Embankment, rock, 595 cubic yards, at $2.25 per cubic yard	1,338	75
Excavation, 2,265 cubic yards, at 30 cents per cubic yard	679	50
Sheet piling, pine, 27,360 feet, B. M., at $20 per M	547	20
	6,304	95

Total length of dike, 620 feet; maximum height, 8.4 feet.

Dike No. 4, for 14-foot flowage.

Embankment, earth, 3,599 cubic yards, at 50 cents per cubic yard	$1,799	50
Embankment, gravel, 256 cubic yards, at $1.50 per cubic yard	384	00
Embankment, rock, 400 cubic yards, at $2.25 per cubic yard	900	00
Excavation, 1,742 cubic yards, at 30 cents per cubic yard	522	60
Sheet piling, pine, 21,780 feet, B. M., at $20 per M	435	60
	4,041	70

Total length of dike, 490 feet; maximum height, 6.4 feet.

Dike No. 4, for 12-foot flowage.

Embankment, earth, 1,050 cubic yards, at 50 cents per cubic yard	$525	00
Embankment, gravel, 111 cubic yards, at $1.50 per cubic yard	166	50
Embankment, rock, 171 cubic yards, at $2.25 per cubic yard	384	75
	1,076	25

Total length of dike, 380 feet; maximum height, 4.4.

RECAPITULATION.

Total cost of 3,530 linear feet of diking, for 16 feet flowage:

Embankment, earth, 32,666 cubic yards, at 50 cents per cubic yard	$16,333	00
Embankment, gravel, 2,074 cubic yards, at $1.50 per cubic yard	3,111	00
Embankment, rock, 3,015 cubic yards, at $2.25 per cubic yard	6,783	75
Excavation, 11,887 cubic yards, at 30 cents per cubic yard	3,566	10
Sheet piling, pine, 162,132 feet, B. M., at $20 per M	3,242	64
Superintendence	1,500	00
	34,536	49

Total cost of 2,560 linear feet of diking, for 14 feet flowage:

Embankment, earth, 21,555 cubic yards, at 50 cents per cubic yard	$10,777	50
Embankment, gravel, 1,462 cubic yards, at $1.50 per cubic yard	2,193	00

Embankment, rock, 2,217 cubic yards, at $2.25 per cubic yard	$4,988 25
Excavation, 8,549 cubic yards, at 30 cents per cubic yard	2,564 70
Sheet piling, pine, 102,828 feet, B. M., at $20 per M	2,056 56
Superintendence	1,000 00
	23,580 01

Total cost of 1,950 linear feet of diking, for 12 feet flowage:

Embankment, earth, 9,489 cubic yards, at 50 cents per cubic yard	$4,744 50
Embankment, gravel, 770 cubic yards, at $1.50 per cubic yard	1,155 00
Embankment, rock, 1,164 cubic yards, at $2.25 per cubic yard	2,619 00
Excavation, 3,154 cubic yards, at 30 cents per cubic yard	946 20
Sheet piling, pine, 21,120 feet, B. M., at $20 per M	422 40
Superintendence	500 00
	10,387 10

NOTE.—Length of the dikes given are from measurements taken along the crest of embankments. The heights are taken from points 3 feet below the surface of the ground to the top of embankment.

Total cost of diking for 16 feet flowage	$34,536 49
Total cost of diking for 14 feet flowage	23,580 01
Total cost of diking for 12 feet flowage	10,387 10

Some of the amounts may appear large, but when the distance of the reservoir from any supply depot is considered, and its inaccessibility through the want of proper facilities for transportation, as well as the difficulties that will be experienced in obtaining a portion of the material needed, the amounts will not appear in excess. Rock, which is estimated at $2.25 per cubic yard, can only be obtained in sufficient quantities from Cass Lake, 27 miles distant. Gravel, placed at $1.50 per cubic yard, will also entail considerable expense in its procurement. Sheet piling, estimated at $20 per thousand feet, board measure, can either be hewed out or sawed near the works. The latter method will require a temporary saw-mill. For these reasons any less estimate would be inadequate for the proper construction of the dikes.

Almost the entire country subject to overflow is utterly worthless, largely consisting of cedar and tamarac swamps, and "jack" pine country, unfit alike for cultivation or timber. The lands subject to overflow of the greatest value to the present occupants of the country—the Cass and Winnibigoshish Lake Indians—consist of from 100 to 150 acres of wild rice. Extensive tracts of hay meadow will also be flooded, but this land is utilized to but a slight extent by the Indians. Some Norway and white pine would be covered to a depth of from 3 to 4 feet when the reservoir is full, but the amount is inappreciable in comparison with the large extent of pine land situated above flowage.

The Indians in some localities would also suffer damage to property. Their transportation routes would be benefited by the establishment of the reservoir, as their chief means of conveyance is by canoe. There is some land suitable for agricultural purposes, but it lies mostly above flowage.

The Indians, collectively, would suffer serious loss but in one respect, the destruction of their wild-rice fields, and these yield but a small per cent. of the rice gathered in that country.

Winnibigoshish Lake reservoir, in addition to being the largest of any of the others proposed, presents two very favorable conditions to its economic construction:

1. The small amount of timber lands to be flooded; and
2. The reservation of the lands to the Indians, which places this section of country under the direct control of the government, thereby entailing but a comparatively small outlay for damaged property.

Accompanying this report will be found a general map showing Gull Lake and Pine River reservoirs. The more detailed maps will be completed as soon as practicable.

I am greatly indebted to Messrs. H. N. Elmer, Albert R. Starkey, and C. M. Douglass for hearty, efficient, and intelligent co-operation in the several surveys placed under my charge.

Very respectfully, your obedient servant,

W. S. MORTON,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

APPENDIX D.

EXAMINATION OF THE DIVIDE BETWEEN LAKE WINNIBIGOSHISH AND BALL CLUB LAKE.

REPORT OF MR. R. DAVENPORT, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., January 11, 1881.

SIR: I have the honor to submit the following report of an examination of the Divide between Lake Winnibigoshish and Ball Club Lake:

As instructed in letter of December 18, 1880, I started from Aitken, Minn., taking with me three men and team and driver, reaching Lake Winnibigoshish on December 27. After making a preliminary examination on the 28th, I started a level line on the 29th to the small lake in sections 3 and 10, township 146, range 26 west, as shown by plotted line on general map. I found the lake to be at an elevation of 341.709 feet, Mississippi River levels, equivalent to an elevation of 8.095 feet above the water at the dam-site in 1878. I then continued the line of levels up the creek, in sections 10 and 15 of the same township, until I reached an elevation of 348.698 water in the creek, equivalent to 15.084 feet above the water on the dam-site in 1878, and an elevation of the cedar swamp, on both sides of the creek, of 350.483 feet, equivalent to an elevation of 16.869 feet above the water at the dam-site in 1878.

The creek at the point at which the line was ended is about 3 feet wide and 1 foot deep, and has apparently a rapid fall through a very dense cedar swamp. In the last 1,000 feet of the line, probably 1½ miles of the creek, six or eight small streams join the main creek from either side, showing that the entire slope of the swamp is toward Lake Winnibigoshish. I should estimate that the Divide is at least 1 mile above the point at which the line was ended. The additional rise in the swamp must also be considerable, to develop so large and well-defined a stream in so short a distance.

Very respectfully, your obedient servant,

R. DAVENPORT,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

APPENDIX E.

EXAMINATION FOR A STORAGE RESERVOIR AT POKEGAMA FALLS, ON THE UPPER MISSISSIPPI RIVER.

REPORT OF MR. G. O. FOSS, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 10, 1880.

SIR: I respectfully submit the following report of an examination for a storage reservoir at Pokegama Falls, on the upper Mississippi River.

The object of the examination was to see if the five dams proposed by Major Farquhar in 1874 could not be replaced by one high dam located at Pokegama Falls. Thirty feet were fixed on as the height of the proposed dam; this gives a flowage of 6 feet over low water of Lake Winnibigoshish and 3.1 feet over Leech Lake, the water of 1878 being taken as low-water.

The party left Saint Paul October 4 and reached Grand Rapids, 3 miles below Pokegama Falls, October 12.

Owing to the lateness of the season and the wide extent of country to be flooded by such a dam, there was not time for any connected survey. The work was therefore confined to a thorough exploration with the level of all doubtful points. Compass lines were run for lines of dikes to assist in their proper location.

The country around Pokegama Lake is high and broken, the ridges varying in elevation from 30 to 100 feet above the lake. Further up the Mississippi the valley opens out, and the hard ground has an elevation of only 10 to 15 feet above the river, the general character of the country being low and flat. Such is the character of the peninsula between the mouth of the Vermillion River and Mud Lake, nearly all of which would be flooded by a 30-foot dam.

My examinations were chiefly confined to the country lying between Pokegama Lake and the Mississippi River, and disclose the fact that the dividing ridge was broken in several places, requiring large dikes to prevent the water from finding a new chan-

nel to the Mississippi below the dam-site. Five dikes in all will be necessary, three of them very long ones.

About a half mile south of the dam-site is a swamp connected by low ground with the river above and below the falls. Dike No. 1 will cross this swamp and join the ridge on which the south end of the dam will rest with a high ridge near Pokegama Lake. It will be 4,440 feet long. Dike No. 2 would cross a depression in the last-named ridge, and would be of little consequence as to cost. The proposed dike No. 3, in sections 24 and 25, township 55 north, range 26 west, and in section 30, township 55 north, range 25 west of fourth principal meridian, would be 4,750 feet long. There is a swamp at this point connecting Pokegama Lake with the Mississippi River, about 1 mile above Grand Rapids. The dike would cross this swamp near the lake in section 25, and run thence southeast along the ridge between the swamp at the head of bay in section 30 and the creek flowing north from Horseshoe Lake to the Mississippi.

Horseshoe Lake is situated in sections 30 and 31, township 55 north, range 25 west of fourth principal meridian, and is 12 feet below the proposed flowage line. West of this lake, in section 31, is a tamarac swamp connecting with it and with Pokegama Lake. The examinations around Horseshoe Lake were chiefly confined to a personal exploration. One line was run for a dike (No. 4), and the remaining diking I have estimated from this.

Dike No. 5 was located at the end of the southeast arm of the lake. Here a succession of small lakes and swamps connect Pokegama Lake with the Mississippi River, which is only 3 miles distant.

The highest ground on which the dike was located lies close to Pokegama Lake. East of this there is a large swamp, which outlets by a creek into the Mississippi. This dike would be 7,600 feet long. Soundings were taken in Pokegama Lake to see if the proposed dike could not be shortened by crossing the lake, but the best line of soundings showed 33 feet of water, and other lines 40 and 46 feet.

The following tables show the estimated cost of the different dikes proposed:

Dike No. 1.

Embankment, earth, 128,045.8 cubic yards (4,440 linear feet), at 50 cents per cubic yard	$64,022 90
Inner slope of embankment, gravel, 6,100.2 cubic yards, at $1.50 per cubic yard	9,150 30
Paving, rock, 9,145.3 cubic yards, at $1.75 per cubic yard	15,894 27
Puddle wall, clay and gravel, 30,155.5 cubic yards (3,935 linear feet), at $2.50 per cubic yard	75,388 75
Excavation for puddle wall, earth, 22,363.3 cubic yards, at 60 cents per cubic yard	13,417 98
Sheet piling, pine, 756,480 feet, B. M., at $14 per M	10,590 72
For driving sheet piling, 126,080 linear feet, at 5 cents per foot	6,304 00
Longitudinal timbers, pine, 84,053 feet, B. M., at $14 per M	1,176 74
Struts, 15,760 linear feet, at 5 cents per foot	788 00
Total cost of dike	196,733 66

Dike No. 2.

Embankment, earth, 3,507.2 cubic yards (600 linear feet), at 50 cents per cubic yard	$1,753 60
Inner slope of embankment, gravel, 296.3 cubic yards, at $1.50 per cubic yard	444 45
Paving, rock, 444.5 cubic yards, at $1.75 per cubic yard	777 87
Total cost of dike	2,975 92

Dike No. 3.

Embankment, earth, 88,170.4 cubic yards (4,750 linear feet), at 50 cents per cubic yard	$44,385 20
Inner slope of embankment, gravel, 4,829 cubic yards, at $1.50 per cubic yard	7,318 05
Paving, rock, 7,318 cubic yards, at $1.75 per cubic yard	12,806 50
Puddle-wall, clay and gravel, 21,636.9 cubic yards (3,540 linear feet), at $2.50 per cubic yard	54,092 25
Excavation for puddle-wall, earth, 18,592.8 cubic yards, at 60 cents per cubic yard	11,155 68
Sheet-piling, pine, 672,000 feet, B. M., at $14 per M	9,408 00

For driving sheet-piling, 112,000 linear feet, at 5 cents per linear foot	$5,600 00
Longitudinal timbers, pine, 74,667 feet, B. M., at $14 per M	1,045 33
Struts, 14,000 linear feet, at 5 cents per linear foot	700 00
Total cost of dike	146,511 01

Dike No. 4.

Embankment, earth, 4,989 cubic yards (234 linear feet), at 50 cents per cubic yard	$2,494 50
Inner slope of embankment, gravel, 282.2 cubic yards, at $1.50 per cubic yard	423 30
Paving, rock, 423.3 cubic yards, at $1.75 per cubic yard	740 77
Puddle-wall, clay and gravel, 1,315.5 cubic yards (225 linear feet), at $2.50 per cubic yard	3,288 75
Excavation for puddle-wall, earth, 1,111.2 cubic yards, at 60 cents per cubic yard	666 72
Sheet-piling, pine, 42,240 feet, B. M., at $14 per M	591 36
For driving sheet-piling, 7,040 linear feet, at 5 cents per foot	352 00
Longitudinal timbers, pine, 4,480 feet, B. M., at $14 per M	62 72
Struts, 840 linear feet, at 5 cents per foot	42 00
Total cost of dike	8,662 12

Diking around Horseshoe Lake, including Dike No. 4:

Estimated length of diking	800 feet.
Estimated legth of puddle wall	400 feet.
Estimated cost of diking	$25,986 36

Dike No. 5.

Embankment, earth, 193,369.2 cubic yards (7,600 linear feet), at 50 cents per cubic yard	$96,684 60
Inner slope of embankment, gravel, 9,832.9 cubic yards, at $1.50 per cubic yard	14,749 35
Paving, rock, 14,749.3 cubic yards, at $1.75 per cubic yard	25,811 27
Puddle-wall, clay and gravel, 48,819.7 cubic yards (7,375 linear feet), at $2.50 per cubic yard	122,049 25
Excavation for puddle-wall, earth, 39,794.3 cubic yards, at 60 cents per cubic yard	23,876 58
Sheet piling, pine, 1,406,592 feet, B. M., at $14 per M	19,692 29
For driving sheet-piling, 234,432 linear feet, at 5 cents per foot	11,721 60
Longitudinal timbers, pine 156,288 feet, B. M., at $14 per M	2,188 03
Struts, 29,304 linear feet, at 5 cents per foot	1,465 20
Total cost of dike	318,238 17

SUMMARY.

Cost of dike No. 1	$196,733 66
Cost of dike No. 2	2,975 92
Cost of dike No. 3	146,511 01
Cost of diking around Horseshoe Lake	25,986 36
Cost of dike No. 5	318,238 17
Total cost of diking	690,445 12
Total number of linear feet of earth embankment	18,190
Total number of linear feet of puddle wall	15,250

The top of the embankment was estimated 8 feet above the flowage line of the dam and the top of the puddle wall 1 foot above flowage. As no borings were taken, the puddle wall, was estimated as extending uniformly 10 feet below the surface.

The following is an estimate of the cost of the dam. It is for an earth rmbankment 18 feet wide, with slopes of 2 to 1, and with masonry sluice-ways. The estimate for masonry was made for granite rock brought from Sauk Rapids, Minnesota. If the rock at Pokegama Falls is found suitable, it will reduce the estimate abont $75,000. The rock at the falls is a quartzite, or quartzose sandstone, of a hard texture, and shows but little wear from the action of water, so that I see no reason to doubt its durability. It is doubtful, however, if it can be quarried in regular blocks, owing to

its hardness and the presence of irregular seams, and it would be necessary to open a quarry to test its adaptability to the work.

ESTIMATE OF COST OF DAM.

6,537 cubic yards of masonry, at $35 per cubic yard		$228,795 00
22 sluice-gates, at $300 each		6,600 00
Earth and gravel embankment:		
98,953 cubic yards earth, 10 per cent. added, at 50 cents per cubic yard	$49,476 50	
3,184 cubic yards gravel, at $1.50 per cubic yard	4,776 00	
4,776 cubic yards rock, at $1.75 per cubic yard	8,358 00	
13,895 cubic yards puddle-wall, at $2.50 per cubic yard	34,737 50	
		97,348 00
Excavation for filling for gate foundations:		
300 cubic yards rock excavation, at $5 per cubic yard	1,500 00	
300 cubic yards concrete, at $5 per cubic yard	1,500 00	
		3,000 00
Coffer-dam		11,780 00
Log-sluices		7,303 04
Cost of diking		690,445 12
Contingencies of engineering, 10 per cent		104,527 12
Superintendence of dam and dikes		10,000 00
Bailing and draining		2,000 00
Total cost		1,161,798 28

Major Farquhar's estimate of the cost of the five dams at Winnibigoshish, Leech, and Mud lakes, Vermillion River, and Pokegama Falls was only $400,841.84, as given in his report of 1875.

Besides the cost of construction, the land damages would be increased, much of the land belonging to private parties. The flooding of timber and swamp lands also increases the extent of surface exposed to evaporation. I have estimated the surface area of the reservoir at 11,142,741,800 square feet, or nearly 400 square miles, and the capacity at 71,019,935,280 cubic feet. This estimate is confined to swamp and water areas known to be flooded, and the actual surface exposed to evaporation would be still greater.

The area of the watershed above Pokegama Falls is 3,432 square miles, or 95,678,668,800 square feet. Deducting from this the area of the reservoir, 11,142,741,800 square feet, from which, it is assumed, the evaporation will equal the rainfall, and there is left a watershed area of 84,535,927,000 square feet.

Assuming that 0.7 of a foot of rainfall over this area will find its way into the reservoir, we have an available supply of 59,175,148,900 cubic feet. This gives an excess of reservoir capacity over the supply of 11,844,786,380 cubic feet, equivalent to about 1 foot in depth over the entire reservoir.

Lines of levels were run north from Pokegama Falls, exploring the country between Bass Lake and Prairie River; also, south of Pokegama Lake and up the creek emptying into the southwest arm of the lake known as Pokegama Brook. These points were all found to be safe from run-arounds. An attempt was made to run levels up the Vermillion River, but the line was abandoned owing to the severe weather.

The Mississippi River was gauged below Grand Rapids October 13, with the following results:

Date.	Station one-third of a mile below Grand Rapids.	Height above mean low-water.	Area of cross-section.	Mean velocity of river, cubic feet per second.	Discharge in cubic feet per second.	Average.
1880.		*Feet.*	*Feet.*			
Oct. 13	1st observation	0.86	612.0	2.183	1335.8	1367.1
	2d observation	0.86	612.0	2.238	1369.6	
	3d observation	0.86	612.0	2.281	1396.0	
	2d observation	(*)	519.7	2.144	1058.5	.....

* Reduced to mean low-water.

In reducing the second observation to low-water the formula $V : V' :: \sqrt{r} : \sqrt{r'}$ was used, in which

V = Known velocity.
V′ = Required velocity.
r = Mean radius of cross-section.
r' = Mean radius of reduced cross-section.

This agrees very closely with observations taken October 15 1879, and given in your report of December 12, 1879. I copy them for comparison:

Date.	Station below Grand Rapids.	Stage of water below mean low-water.	Area of cross-section.	Mean velocity of river, cubic feet per second.	Discharge in cubic feet per second.	Average.
1879.		*Feet.*	*Feet.*			
Oct. 15	1st observation	0.4	853.3	1.161	941.0	969.0
	2d observation	0.4	853.3	1.249	1011.0	
	3d observation	0.4	853.3	1.221	990.0	
	4th observation	0.4	853.3	1.151	934.0	

In returning, the party reached Saint Paul November 16.

An additional estimate has been made for a 24-foot dam, the flowage of which will extend to the foot of the proposed dam at Lake Winnibigoshish. The surface overflowed is estimated at 83.7 square miles, or 2,333,426,400 square feet, and the reservoir capacity at 25,644,637,760 cubic feet.

The drainage area below Lake Winnibigoshish is 1,998 square miles, or 55,701,043,200 square feet. Deducting the surface area of the reservoir there remain 53,367,616,800 square feet. Allowing 0.7 of a foot as the amount of rainfall available over this surface, and we have a supply of 37,357,331,760 cubic feet. This gives a surplus supply of 11,712,694,000 cubic feet passing over the Pokegama Dam.

The following tables show the estimated cost of the dam and dikes; four dikes will be required with this height of dam; dike No. 2 of the previous estimate is not needed, and the remaining dikes are designated as Nos. 1, 3, 4, and 5, to correspond with the number shown on the map. The top of the diking was estimated for 6 feet above the flowage line, and the top of the puddle wall 1 foot above flowage:

Estimate for 24-foot dam.

Sluice-ways, masonry, 5,605 cubic yards, at $35 per cubic yard	$196,175 00
Sluice-gates, 22, at $300 each	6,600 00
Embankment, 10 per cent. added, earth, 69,325 cubic yards, 1,650 linear feet, at 50 cents per cubic yard	34,662 50
Inner slope of embankment, gravel, 2,354 cubic yards, at $1.50 per cubic yard	3,531 00
Paving, rock, 3,530 cubic yards, at $1.75 per cubic yard	6,177 50
Puddle-walls, clay and gravel 4,375 cubic yards, 1,360 linear feet, at $2.50 per cubic yard	10,937 50
Excavation for puddle-wall, earth, 7,703 cubic yards, at 60 cents per cubic yard	4,621 80
Excavation for gate foundations, rock, 300 cubic yards, at $5 per cubic yard	1,500 00
Filling for gate foundations, concrete, 300 cubic yards, at $5 per cubic yard	1,500 00
Log-sluices, pine (iron included in cost price), 347,872 feet, B. M., at $20 per M	6,957 44
Log-sluices, bolting to rock bottom	345 60
Coffer-dam, timber, 34,800 feet, B. M., at $20 per M	696 00
Coffer-dam, puddle-wall, 1,423 cubic yards, at $2.50 per cubic yard	3,557 50
Coffer-dam, earth embankment, 4,000 cubic yards, at $1 per cubic yard	4,000 00
Coffer-dam, excavation for foundation, 1,100 cubic yards, at 60 cents per cubic yard	660 00
Total cost of dam	281,921 84

Contingencies of engineering, 10 per cent	$28,192 18
Bailing and draining for dam and dikes	2,000 00
Superintendence	5,000 00
Total cost	317,114 02

Dike No. 1.

Embankment, earth, 57,388.1 cubic yards, 3,800 linear feet, at 50 cents per cubic yard	$28,694 05
Inner slope of embankment, gravel, 4,267.7 cubic yards, at $1.50 per cubic yard	6,401 55
Paving rock, 6,401.5 cubic yards, at $1.75 per cubic yard	11,202 62
Excavation for embankment, earth, 24,182.2 cubic yards, at 40 cents per cubic yard	9,672 88
Puddle-wall, clay and gravel, 17,827.9 cubic yards, 3,040 linear feet, at $2.50 per cubic yard	44,569 75
Excavation for puddle-wall, earth, 15,993.2 cubic yards, at 60 cents per cubic yard	9,595 92
Sheet-piling, pine, 583,680 feet, B. M., at $14 per M	8,171 52
For driving sheet-piling, 97,280 linear feet, at 5 cents per foot	4,864 00
Longitudinal timbers, pine, 64,853 feet, B. M., at $14 per M	907 94
Struts, 12,156 linear feet, at 5 cents per foot	608 00
Total cost of dike	124,688 23

Dike No. 3.

Embankment, earth, 32,218.5 cubic yards, 3,000 linear feet, at 50 cents per cubic yard	$16,109 25
Inner slope of embankment, gravel, 2,716.1 cubic yards, at $1.50 per cubic yard	4,074 15
Paving, rock, 4,074.1 cubic yards, at $1.75 per cubic yard	7,129 67
Excavation for embankment, earth, 15,590.8 cubic yards at 40 cents per cubic yard	6,236 32
Puddle-wall, clay and gravel, 8,548 cubic yards, 1,580 linear feet, at $2.50 per cubic yard	21,370 00
Excavation for puddle-wall, earth, 8,096.1 cubic yards, at 60 cents per cubic yard	4,857 66
Sheet piling, pine, 303,360 feet, B. M., at $14 per M	4,247 04
For driving sheet piling, 50,560 linear feet, at 5 cents per foot	2,528 00
Longitudinal timbers, pine, 33,707 feet, B. M., at $14 per M	471 90
Struts, 6,320 linear feet, at 5 cents per foot	316 00
Total cost of dike	67,339 99

Dike No. 4.

Embankment, earth, 1,954.2 cubic yards, 220 linear feet, at 50 cents per cubic yard	$977 10
Inner slope of embankment, gravel, 195.3 cubic yards, at $1.50 per cubic yard	292 95
Paving rock, 293 cubic yards, at $1.75 per cubic yard	514 75
Excavation for embankment, earth, 1,122.3 cubic yards, at 40 cents per cubic yard	448 92
Puddle-wall, clay and gravel, 779.9 cubic yards, 180 linear feet, at $2.50 per cubic yard	1,949 75
Excavation for puddle-wall, earth, 890.5 cubic yards, at 60 cents per cubic yard	534 30
Sheet piling, pine, 34,560 feet, B. M., at $14 per M	483 84
For driving sheet piling, 5,760 linear feet, at 5 cents per foot	288 00
Longitudinal timbers, pine, 3,840 feet, B. M., at $14 per M	53 76
Struts, 720 linear feet, at 5 cents per foot	36 00
Total cost of dike	5,579 37

Dike No. 5.

Embankment, earth, 79,862 cubic yards, 7,200 linear feet, at 50 cents per cubic yard	$39,931 00
Inner slope of embankment, gravel, 6,630 cubic yards, at $1.50 per cubic yard	9,945 00

MAP

SHOWING LOCATION OF

PROPOSED 30 FT. RESERVOIR DAM AND DYKES

AT

POKEGAMA FALLS

on the

MISSISSIPPI RIVER.

FROM SURVEYS MADE DURING THE SEASON OF 1880

by

G. O. FOSS ASST. ENGINEER,

Under direction of

CAPT. CHAS. J. ALLEN,

CORPS OF ENGINEERS U.S.A.

Note:

30' Flowage contour denoted thus

Location of dykes denoted thus

figures denote elevations above the sea.

Area of Watershed – Area of Reservoir x 0.7 ft = Supply.

To accompany report of Capt. Chas. J. Allen.
Jan 16th 1881.

R.27 R.26 R.25 R.24

T.56. T.55 T.54 T.53

5th PRINCIPAL MERIDIAN

DEER LAKE

STEPHENS LAKE

WHITE OAK LAKE

TRAIL

PORTAGE

BIG MUSKEG LAKE

CUT OFF LAKE

MISSISSIPPI RIVER

BASS LAKE

SHOAL LAKE

1337

PRAIRIE LAKE

GRANITE FALLS

TRAIL RIVER

LITTLE BASS LAKE

PROPOSED DAM ELEVATION OF WATER ABOVE SEA LEVEL 1244.3

POKEGAMA FALLS

DYKE No 1

DYKE No 2

DYKE No 3

DYKE No 4

GRAND RAPIDS

1243.4 W.S. below Rapids

TROUT LAKE

SWAN RIV.

RICE LAKE

HORSESHOE LAKE

POKEGAMA LAKE

MISSISSIPPI RIVER

30 Ft Dam.

Area of Watershed ---- 95 678 668 800 sq ft

Supply from do ---- 59 175 148 900 cu ft

Area of Reservoir ---- 711 427 418 00 sq ft

Capacity of do ---- 71 069 352 80 cu ft

24 Ft Dam.

Area of Watershed ---- 55 701 043 200 sq ft

Supply from do ---- 37 357 331 760 cu ft

Area of Reservoir ---- 2 333 426 400 sq ft

Capacity of do ---- 2 584 463 760 cu ft

SIS-E-BA-KWET LAKE

QUAM-BUGH-E-WA-GET-NO-KA

HALE LAKE

DYKE No 5

70' flowage above Pokegama Lake.

Water Shed of Pokegama Brook

POKEGAMA BROOK

SPLIT HAND LAKE

SPLIT HAND RIVER

WEST FORK OF HILL RIVER

Paving, rock, 9,945 cubic yards, at $1.75 per cubic yard	$17,403 75
Excavation for embankment, earth, 38,565.7 cubic yards, at 40 cents per cubic yard	15,426 28
Puddle-wall, clay and gravel, 23,862.5 cubic yards, 5,130 linear feet, at $2.50 per cubic yard	59,656 25
Excavation for puddle-wall, earth, 25,163.4 cubic yards, at 60 cents per cubic yard	15,098 04
Sheet piling, pine, 984,960 feet, B. M., at $14 per M	13,789 44
For driving sheet piling, 164,160 linear feet, at 5 cents per foot	8,208 00
Longitudinal timbers, pine, 109,440 feet, B. M., at $14 per M	1,532 16
Struts, 20,520 linear feet, at 5 cents per foot	1,026 00
Total cost of dike	182,015 92

SUMMARY.

Estimated cost of dike No. 1	$124,688 23
Estimated cost of dike No. 3	67,339 99
Estimated cost of dike No. 4	5,579 37
Estimated cost of dike No. 5	182,015 92
Total cost of diking	379,623 51
Contingencies of engineering, 10 per cent	37,962 35
Superintendence	5,000 00
Total	422,585 86
Estimated cost of dam	317,114 02
Total cost of dam and dikes	739,699 88
Total number of linear feet of diking	14,220
Total number of linear feet of puddle-wall	10,030

Very respectfully, your obedient servant,

G. O. Foss,
Assistant Engineer.

Capt. CHARLES J. ALLEN,
Corps of Engineers, U. S. A.

APPENDIX H.

TABLES OF AMOUNT OF AVAILABLE ANNUAL RAINFALL FROM THE WATERSHEDS TRIBUTARY TO THE MISSISSIPPI RIVER AT SAINT PAUL, FRIDLEY'S BAR, SAUK RAPIDS, AND BRAINERD, FINDING ITS WAY INTO THE WATER COURSES. COMPUTED BY MR. J. P. FRIZELL, ASSISTANT ENGINEER.

Discharge of the Mississippi River at Saint Paul.

* * * * * * *

Total discharge of the Mississippi River at Saint Paul, from April 9 to November 18, 1875, 721,759,593,600 cubic feet; 71,696,808,000 cubic feet equals the quantity from November 18 to April 9 assumed at 1 foot above low-water; total for the year, 793,456,401,600 cubic feet, which is equivalent to 9.3 inches on the drainage-ground of 36,741 square miles. The assumption of 1 foot above low-water is in accordance with the present condition of the river. which is about 2 feet 9 inches on the gauge, with ice 18 to 24 inches thick.

* * * * * * *

Total discharge of the Mississippi River at Saint Paul, from March 9 to December 7, 1879, 274 days, 275,319,907,200 cubic feet.

Discharge of the Mississippi River at Fridley's Bar.

* * * * * *

	Cubic feet.
Total discharge from April 1 to November 17	369,665,164,800
Discharge for balance of the year, 134 days, 5,000 cubic feet per second per day	57,888,000,000
Total discharge for 1875	427,553,164,800

Being 9.16 inches on the drainage-ground of 20,062 square miles.

the Mississippi River at Sauk Rapids.

* * * * * * *

	Cubic feet.
Total discharge from April 18 to October 31, 197 days	221,093,625,600
Flow from April 1 to 17, assumed to increase regularly from low-water, March 31, to 28,885 cubic feet per second, April 18. The rise commenced April 1 as shown by the Saint Anthony gauge	24,288,076,800
Flow from November assumed to dimish uniformly from 6,138 cubic feet per second, October 31, to low-water volume of 4,188 cubic feet per second, November 30	13,382,496,000
Flow for December, January, February, and March assumed at dead low-water. This is about the present volume, January, 1881	43,783,027,200
Total flow of river for 1875, being 9.57 inches on drainage area of 13,602 square miles	302,547,225,600

Discharge of the Mississippi River at Brainerd.

* * * * * * *

	Cubic feet.
Total discharge from April 6 to November 18	142,289,654,400
Remainder of the year, 138 days, at low-water, 2,715 cubic feet per second	32,371,488,000
Total, being 10.5 inches on the drainage-ground of 7,173 square miles	174,661,142,400

APPENDIX I.

EXAMINATIONS AND SURVEYS FOR PROPOSED RESERVOIRS AT SOURCES OF THE MISSISSIPPI RIVER.

REPORT OF MR. CHARLES WANZER, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 30, 1880.

SIR: I hereby respectfully submit a report of the result of the surveys and examinations conducted under your orders during the season of 1880 for the purpose of collecting additional data and information in reference to the proposed reservoirs at the sources of the Mississippi River.

The operations have consisted of the surveys of the proposed reservoirs at the Gull Lake and Pine River tributaries of the Mississippi, and a further examination of the proposed reservoir at Lake Winnibigoshish, at the sources of the Mississippi River, which latter examination was made in order to ascertain the highest possible dam which could with safety be built. This work was placed under the immediate supervision of Mr. W. S. Morton, assistant engineer, and operations in the field were commenced August 10 and completed October 28, 1880.

A second party, under the immediate charge of Mr. G. O. Foss, assistant engineer, was started on October 4, 1880, to make an examination and survey of the dam-site and contiguous country around Pokegama Falls, to ascertain if the five dams proposed by Col. F. U. Farquhar, Corps of Engineers, viz, at Lake Winnibigoshish, Leech Lake, Mud Lake, Vermillion River, and Pokegama Falls, could not be replaced by one high dam at Pokegama Falls. The party returned to Saint Paul on November 16, 1880, having spent 43 days on this work.

We will first consider the results of the survey at Gull Lake.

A suitable location for a dam was found half a mile below the outlet of the lake, at the same position as was selected under the direction of Colonel Farquhar in the season of 1874. Borings for foundations were made on and near the dam-site, and plottings of the same accompany this report. The drainage area of the Guli Lake River is 235.97 square miles.

Assuming the mean annual rainfall of this region to be 25 inches, and one-third of this amount, or seven-tenths of a foot, as the amount actually reaching the dam-site, and discharging through Gull River, we have a yearly supply to the reservoir of 4,604,926,233 cubic feet of water. Reduce this amount by taking from the drainage area, the area of the flowed reservoir, to allow for the increased evaporation surface.

and we have, as the annual available supply for reservoir purposes, the sum of 3,884,905,220 cubic feet. This gives a mean discharge for the year of 123.2 cubic feet per second; or will furnish, as an adjunct to the Upper Mississippi reservoirs, a discharge of 499.6 cubic feet for a low-water period of 90 days. A gauging of Gull River was made, which gave as its discharge 128 cubic feet per second. This agrees within 5 feet per second with the mean discharge deduced from the rainfall and drainage area. The river at the time was at a stage of five-tenths of a foot above low-water, and I believe this stage to be a fair mean for so small a stream, which is frozen up for four months during the year, and has a range of only 2 feet between extreme high and low water. A dam 9 feet high will hold the annual supply to this reservoir, and will give a flowage of 8.5 feet over the low-water surface of Gull Lake.

The character of the country will admit of a 12½-foot height of dam, by the building of two dikes in addition to the dam proper. This height would flow Gull Lake to the depth of 12 feet, and furnish a holding capacity for 10,385,075,643 cubic feet.

It would require a little over 2½ years of mean annual rainfall to fill the reservoir, and would furnish every second year a discharge of 993.9 cubic feet per second, for a period of 90 days. Its additional cost would only be about $15,000, which its enhanced value as a medium of discharge, in seasons of extreme low-water, would more than justify.

The estimated cost of a 9-foot dam at this reservoir is $47,870.33. The estimated cost of a 12-foot dam (including necessary dikes) is $63,141.87.

The main toll-road from Brainerd to the Leech Lake Indian Agency passes through this reservoir and will in two places require embankments to keep it above the flowage line. These embankments will have a total length of 2,160 feet, and should be built of earth with the slopes protected from wave action by riprap. For a 9-foot dam, the cost of this roadway will be $6,333.90. For a 12-foot dam, the cost of this roadway will be $11,406.50.

By changing the location and cutting 7 miles of new road through the woods, at a probable cost of $50 per mile, the expense of both these roadways can be done away with. This would lengthen the present road a little over 2 miles during the summer season, while during the winter months the frozen reservoir would offer better advantages for travel and teams than at present exist. The total cost of the 9-foot and 12-foot dams, estimated both with and without the road embankments, will then be as follows:

Cost of constructing 9-foot dam, with road embankment	$54,204 23
Cost of constructing 12-foot dam, with road embankment	74,548 37
Cost of 9-foot dam, including change of road	48,585 83
Cost of 12-foot dam, including change of road	63,857 37

A tabulated list of the lands to be overflowed by this reservoir is hereto annexed. These lands have been carefully estimated, and can be relied on as being nearly correct, and I believe the prices per acre will cover all resultant damages, provided pernicious combinations of landholders can be avoided. Only the lands actually submerged are included in the list, and probably $1,000 should be added to their value to cover any claim for damages that may arise from the proposed changing of the Leech Lake road.

The holding-ground of this reservoir will be largely confined to 25 natural lakes, which precludes any great increase in the evaporation area. Of the character of the country adjoining these lakes Assistant Morton says: "The banks of the lakes are, in general, high. Comparatively few swamps were found, while the valuable lands (timber lands) are almost entirely above flowage. The general character of the soil is a fine sand, varying in depth from 4 to 15 feet. The timber on a large portion of the reservoir is almost worthless. Some hay meadows were found, and will be subject to overflow, and these in addition to three farms, and their improvements, will comprise a large percentage of the damages to lands by overflow."

Pelican Lake was examined in reference to adding its drainage area to that of Gull Lake. The lake has a surface area of 13.7 square miles, and a drainage area of 31.39 square miles. Its annual supply for reservoir purposes would be 612,572,083 cubic feet. The lake has no outlet during low-water, and its supply is evicently expended by evaporation and percolation into Pelican Brook; therefore, any supply that would be obtained from this source by means of a cut through the dividing ridge into Gull Lake, would be of no practical value.

At the Pine River reservoir the most suitable location for a dam-site was found to be on Pine River, one fourth of a mile below Cross Lake. The country on either side of the dam-site has a general elevation of from 20 to 25 feet above Cross Lake, but an examination demonstrated that a dam 17.5 feet in height is the highest that can be built with security from overflow and runarounds. Borings for foundations were made at and near the selected dam-site, and the results are shown on the accompanying plotting. The holding-ground of this reservoir consists mainly of 21 lakes. The drainage area of the Pine River basin, after deducting the area of the reservoir when filled, will

be 503.64 square miles. This area will furnish an annual supply to the reservoir of 9,828,474,163 cubic feet.

The height of dam adopted will furnish a holding-ground for 7,474,384,104 cubic feet, which leaves a surplus supply of 2,354,090,059 cubic feet. Three supplemental reservoirs can be constructed—one at Norway Lake, one at South Fork of Pine River, and one at Mountain Lake—which will retain 2,017,529,779 cubic feet of this surplus supply and increase the amount to be discharged from the main Pine River dam to 9,491,913,883 cubic feet, which will furnish to the Mississippi River every year the amount of 1,220.6 cubic feet of water per second for the period of 90 days.

The cost of the main Pine River dam, including the necessary amount of additional diking, log-sluice, &c., will be	$80,158 09
The three supplemental dams will cost	44,000 00
Total to be expended on this reservoir	124,158 09

These estimates, as well as those for the Gull Lake reservoir, are made with the view of puddle walls, inclosed in the embankments, and extending down to the clay and hard-pan bottoms, and are based on the information derived from the borings taken at the dam-sites. The cost of the construction of these reservoirs is greatly in excess of the estimates made by Colonel Farquhar, but I believe they are none too high.

A list of the lands to be overflowed by the Pine River reservoir, and their estimated value, has been compiled by Mr. Morton, and is undoubtedly nearly correct.

The work at Lake Winnibigoshish was principally confined to the southern and eastern sides of the lake. Level-lines were run both east and west from the dam-site, and the number of linear feet of diking required for a 12-foot, 14-foot, and 16-foot height of dam was determined as follows:

A 12-foot flowage will require 1,950 linear feet of diking; cost	$10,387 10
A 14-foot flowage will require 2,560 linear feet of diking; cost	23,580 00
A 16 foot flowage will require 3,530 linear feet of diking; cost	34,536 49

These flowage lines are estimated as above the low-water of 1878 in Lake Winnibigoshish, which was, during that season, 2 feet lower than when the surveys and estimates were made by Colonel Farquhar, 1874. The 16-foot dam and dikes, above the low-water of 1878, would therefore have to be built to give the same holding capacity to the reservoir as has been already reported for a 14-foot rise above the water of 1874, viz, a capacity of 45,754,204,380 cubic feet.

A 14-foot dam above the low-water of 1878 would afford a capacity of only 37,128,801,660 cubic feet, and a 12-foot dam, above the datum of 1878, would still further reduce its capacity to about 28,000,000,000 cubic feet.

The elevation of Bowstring Lake was ascertained to be 30 feet above the water in Lake Winnibigoshish, and the drainage of its (Bowstring Lake) basin was found to be into Rainy Lake River, and thence into Hudson's Bay. The drainage area of Bowstring Lake comprises 458 square miles (12,768,307,201 square feet). This area has hitherto been considered as tributnry to Lake Winnibigoshish and the Mississippi River, and must therefore now be subtracted from the area as reported in 1878 and 1879. The report of 1878 gives area of Lake Winnibigoshish basin as 1,892 square miles.

Supply, figured as 0.7 foot over this area = 36,922,152,960 cubic feet. This, as corrected, should be: Area of Winnibigoshish basin, 1,434 square miles = 39,977,625,600 square feet; supply of Winnibigoshish basin, figured as 0.7 foot over this area = 27,984,337,920 cubic feet; reduction in supply = 8,937,815,040 cubic feet. Supply, as reported in 1878, would furnish, for 90 days = 4,748 cubic feet per second; supply, as corrected, would furnish, for 90 days = 3,599 cubic feet per second; reduction in discharge per second = 1,149 cubic feet.

It will thus be seen that a 12-foot dam above the low-water of 1878 will furnish a storing capacity about equal to the annual supply, while a 16-foot dam above the same plane will furnish holding-ground in excess of the annual supply to the extent of 17,769,866,460 cubic feet.

In the above calculations the entire area of the flowed reservoir has been considered under the head of drainage area, no reduction of the reservoir surface exposed to evaporation having been made. If the reservoir surface is deducted from the drainage area, the annual supply to the reservoir will be reduced to 24,965,446,968 cubic feet, and the excess of the holding capacity over the supply will (by a 16-foot dam) be increased to 20,788,757,412 cubic feet, in which case the capacity would nearly equal the supply for two years.

To construct the dam, log-sluices, and dikes at this reservoir, I think will require at least the sum of $100,000.

Much has been said of the sad results to accrue to the Indians by the construction of this reservoir, on account of the flowing out and destruction of their wild-rice fields. From the trader at Leech Lake (as well as others) I learn that but a very

small quantity of wild rice is gathered by the Indians in Lake Winnibigoshish. He says: "Only the Bowstringers have a very large field of it [wild rice], and mostly all the Winnibigoshish and Cass Lake Indians go there [Bowstring Lake] to pick it. These fields would not be overflowed, and apparently the damage to the Indians by this proposed work would be very slight."

The party under Mr. G. O. Foss, assistant engineer, to whom was delegated the surveys and examinations around Pokegama Falls to ascertain the practicability of one high dam at that point replacing the five dams previously recommended, was only able to make examinations in reference to the danger from runarounds into the Mississippi River below the falls.

There was not sufficient time to run flowage lines which would accurately demonstrate the capacity of the proposed dam, and the figures showing capacity are based on former examinations and known elevations of the country, and are entirely within safe limits.

Mr. Foss finds that 18,190 linear feet (nearly 3½ miles) of diking will have to be constructed in addition to the dam proper, in order to retain the waters tributary to Pokegama Falls. These dikes are principally located on the east side of Pokegama and on the west side of Horseshoe Lakes, and are rendered necessary on account of the swamps and creeks connecting these lakes wieh the Mississippi River. North of the falls the country is found to be free of depressions that can affect the capacity of the proposed reservoir.

The cost of the proposed dikes, made of earth embankment with a puddle wall, extending to the underlying strata of clay, is estimated to be about $700,000. This estimate is based on the supposition of finding clay foundations at an average depth of 10 feet below the surface of the ground. No borings have been made, and actual knowledge of the formation of the country may either reduce or increase this estimate materially.

The cost of the dam designed to be built of earth embankment, on solid-rock foundation, with slopes well protected by gravel and loose rock, and with cut masonry sluices and face walls, is estimated to be about $400,000; or, in close figures, the entire cost of dikes, and dam is estimated to be $1,161,798.28.

The estimate for the dam is certainly none too high to cover all contingencies, unless it is found that the rock in place around the dam-site can be used for building purposes in construction. At the estimated cost, as given, it is calculated to procure the necessary granite for the sluices, &c., at Sauk Rapids. The estimates for the dikes can only be changed by a more accurate knowledge of the formation of the country.

The drainage area tributary to Pokegama Falls is now determined to be 3,432 square miles, or 95,678,668,800 square feet. This, after deducting the area of the reservoir—which will be 11,142,741,800 square feet—will leave as the total available watershed, 84,535,927,000 square feet, which will furnish to the reservoir 59,175,148,900 cubic feet of water, on the basis of 0.7 foot of water being available for reservoir purposes over the entire drainage area.

The holding capacity of this reservoir will be 71,019,935,280 cubic feet, which is an excess of 11,844,786,380 cubic feet over the above computed supply. It will overflow Lake Winnibigoshish to a depth of 6 feet, and Leech Lake to a depth of about 3 feet.

It would seem that the prospective cost of this high dam would certainly condemn it when compared with the far cheaper method of constructing the five smaller dams; and when to these estimates are added the damages to accrue by overflow of lands, which will embrace an area of between 400 and 500 square miles, the economy of the greater number of smaller dams will become more apparent. Something, too, might be said in reference to the constant danger to the whole upper country arising from the impounding of such a vast quantity of water at any one place. Of course every thing that skill and foresight could accomplish would be done to render this dam and its attendant dikes perfectly safe; but leakages are likely to occur, both from bad construction and from the burrowing of small animals (such as muskrats, otter, and mink) under the foundations. These little animals have frequently caused smaller dams to go out by startlng leaks, and they particularly infest the Upper Mississippi region.

The picture of a 30-foot wave, with the backing of a 400-square-mile sheet of water, breaking loose and starting toward the sea, is not a pleasant one to contemplate, and its possibility should, I think, be avoided, unless immense advantages can be demonstrated to compensate for the risk incurred.

As Congress has already ordered the construction of the proposed dam at Lake Winnibigoshish, and as it is supposed that at least that dam will be built, it was considered advisable to make computations for a 24-foot dam at Pokegama Falls, which would flow just to the foot of the Lake Winnibigoshish dam.

The results of these computations are as follows: A flowage of 24 feet above low-water of 1878, at Pokegama Falls will furnish a reservoir with a surface area of 83.7 square miles, equal to 2,333,426,400 square feet. The holding capacity of the reser-

voir will be only 25,644,637,760 cubic feet. The 6-foot reductlon in the height of the flowage decreases the capacity of the reservoir immensely, principally because the flowage line will be below both lakes, Winnibigoshish and Leech, and the holding ground over these two magnificent natural reservoirs will be entirely lost, thus at one blow taken away the surface area of these two lakes, which is nearly 274 square miles.

The drainage area above Pokegama Falls and below Lake Winnibigohish, is 1,998 square miles, equal to 55,701,043,200 square feet, which will leave, after subtracting the overflowed surface of the proposed reservoir, 53,367,616,800 square feet as certainly available for drainage purposes. This area, on the same basis of computation as has been used in prior cases in this report, will furnish an annual supply to the reservoir of 37,357,331,760 cubic feet, or a surplus annual supply over the capacity of the reservoir of 11,712,694,000 cubic feet. This surplus is certainly too large to be lost sight of (amounting to 1,506 cubic feet per second for a period of 90 days), and will require a supplemental reservoir to be constructed in order to retain it.

The construction of the 24-foot dam at Pokegama will require the building of 14,220 linear feet of diking to prevent run-arounds into the Mississippi River below the falls.

These dikes are estimated to cost	$422,585 86
The dam proper estimated to cost	317,114 02
Total cost of dam and dikes	739,699 88

In the above estimates only the actnal cost of constructing the dam and dikes is considered. The damage to overflowed lands cannot be intelligently determined from the amount of information at present in this office.

The style of dam estimated above is the same as that estimated on for a 30-foot dam at the same place, viz: earth embankment with 18 feet width of crest, slopes 2 to 1, with a puddle wall extending through the whole length and down to clay or rock foundations; masonry sluices and slopes well protected by gravel and loose rock.

To retain the surplus supply that would be furnished to this reservoir, a supplemental dam could be constructed at the outlet of Leech Lake, which would easily accommodate the entire quantity of water which would be desired to be impounded. This reservoir, with a 4-foot height of dam above the low-water of 1874, would afford a holding capacity of 22,567,564,800 cubic feet, and would decrease the drainage area directly tributary to Pokegama Falls by 27,906,278,400 square feet, and have an annual supply to itself of 19,534,394,880 cubic feet, and would easily relieve the proposed 24-foot dam at Pokegama of its entire surplus supply.

This dam was estimated by Colonel Farquhar, Corps of Engineers, to cost $55,000, and this sum would, of course, have to be added to the estimated cost of the 24-foot dam at Pokegama in order to make a proper comparison of this proposed system with the original proposition of the five smaller dams.

I see no reason why this proposition of a 24-foot dam at Pokegama Falls should not be condemned on the same grounds as the proposed 30-foot dam at the same place, viz, its excessive cost, with no compensating engineering points in its favor.

Very respectfully, your obedient servant,

CHAS. WANZER,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

Gauged discharges of the Mississippi River for 1880.

Date.	Station.	Height above mean low-water.	Area of cross-section.	Mean velocity.	Discharge per second.
1880.		*Feet.*	*Feet.*		*Cu. Ft.*
Oct. 13	One-third of a mile below Grand Rapids, No. 1	0.86	612.0	2.183	1335.8
13	No. 2	0.86	612.0	2.238	1369.6
13	No. 3	0.86	612.0	2.281	1396.6
Nov. 4	At Grand Rapids, No. 1	0.9	1021.5	1.450	1481.5
4	No. 2	0.9	1021.5	1.453	1484.2
4	No. 3	0.9	1021.5	1.421	1451.4
4	No. 4	0.9	1021.5	1.461	1492.9
4	No. 5	0.9	1021.5	1.442	1473.7
5	No. 6	0.9	1021.5	1.473	1505.2
5	No. 7	0.9	1021.5	1.517	1549.5
5	No. 8	0.9	1021.5	1.476	1508.2
5	No. 9	0.9	1021.5	1.515	1547.6
5	No. 10	0.9	1021.5	1.469	1501.3
5	No. 11	0.9	1021.5	1.548	1582.0

Gauged discharges of the Mississippi River for 1880—Continued.

Date.	Station.	Height above mean low-water.	Area of cross-section.	Mean velocity.	Discharge per second.
1880.		*Feet.*	*Feet.*		*Cu. ft.*
Nov. 5	At Grand Rapids, No. 12	0.9	1021.5	1.493	1525.1
5	No. 13	0.9	1021.5	1.481	1513.0
6	No. 14	0.9	1021.5	1.399	1429.8
6	No. 15	0.9	1021.5	1.395	1425.7
6	No. 16	0.9	1021.5	1.355	1384.8
6	No. 17	0.9	1021.5	1.385	1415.5
6	No. 18	0.9	1021.5	1.388	1417.9
6	No. 19	0.9	1021.5	1.359	1388.2
6	No. 20	0.9	1021.5	1.346	1375.4
6	No. 21	0.9	1021.5	1.389	1419.0
6	No. 22	0.9	1021.5	1.403	1433.3
6	No. 23	0.9	1021.5	1.399	1428.6
Oct. 25	At Sandy Lake, below the mouth, No. 1	0.4	1043.6	1.475	1539.6
25	No. 2	0.4	1043.6	1.449	1512.5
25	No. 3	0.4	1043.6	1.516	1581.9
25	No. 4	0.4	1043.6	1.446	1510.5
26	At Sauk Rapids, No. 1	1.0	1560.5	2.718	4134.7
June 7	At Saint Paul, No. 1	10.0	12895.0	3.607	46512.0

EXAMINATION OF ROCK RIVER, WISCONSIN AND ILLINOIS, WITH A VIEW TO ESTABLISHING THE RESERVOIR SYSTEM UPON THAT RIVER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 23, 1880.

GENERAL: I have the honor to render the following report upon the examination of the Rock River, in Wisconsin and Illinois, made in pursuance of the paragraph in section 2, act of Congress approved June 14, 1880, said paragraph reading as follows:

> Of the sum of one hundred and fifty thousand dollars herein appropriated for surveys and examinations, the sum of fifteen thousand dollars may be expended in the completion of the survey of the reservoir system on the headwaters of the Mississippi River, including Rock River, in Wisconsin and Illinois.

The examination was made during the month of September last by Mr. J. P. Frizell, assistant engineer, who examined the ground sufficiently, gaining at the same time all information possible from reliable sources. His examination was so satisfactory as to results that a full survey was not deemed necessary.

The uppermost point at which a reservoir has been suggested upon the river is near the village of Horicon, at the outlet of what was once a lake, caused by the construction of a dam 9½ feet high at its outlet in 1842. It was, previous to the construction of that dam, a vast marsh. The lake lies mostly in Dodge and Fond du Lac counties, and has a watershed of about 491 square miles. This dam flowed, it is said, about 60 square miles of ground. This overflow caused extensive suits for land damages, amounting to about $150,000, a sum that the owners of the mill privileges, &c., were unable to pay, judgment having been rendered against them. In 1868 the dam was removed by order of the court. Consequently the area has nearly, if not quite, resumed its original condition. The cost of a dam to recreate the lake, or reservoir, to raise the water, say 10 feet, would be about $15,000. The land damages, however, as estimated by Assistant Frizell, could not be less than from $200,000 to $300,000.

The average annual precipitation at Milwaukee, for a period of eight years, has been calculated as 35.33 inches. If we assume, as does Assistant Frizell, that 40 per cent. of this precipitation finds its way into

the stream, the total amount that could be impounded for one year would be 15,056,369,331 cubic feet. But we must allow for evaporation from the surface of the reservoir; assuming such to be about $\frac{1}{4}$ of an inch per day for seven months in the year, we have as the quantity that can be actually impounded in the reservoir about 8,000,000,000 cubic feet for a dam raising the water surface about 10 feet. This amount impounded and concentrated into a period of one hundred days would afford, as an increment to the Rock River below, and to the Mississippi below Rock Island, about 925 cubic feet per second, which increment to the discharge of the Mississippi below Rock Island would be too small to be of benefit to the latter stream. To raise the dam at Horicon so as to afford a greater head than 10 feet would, of course, increase the reservoir capacity; it would also increase the claims for damages for overflow of land in a well-settled country.

The parties in control of the reservoir prior to 1868 regarded the average cash value of the water discharged from it as $15,000 per annum. These remarks as to a dam at Lake Horicon would appear to settle the question. It only seems necessary to touch cursorily upon the river below it.

Beaver Dam Lake, in Dodge County, has an area of about 6,000 acres, and is created entirely by a dam at the village of Beaver Dam, the water having been raised about 6 feet. It is possible that the reservoir capacity could be somewhat increased by raising the dam, but not to insure any benefit thereby.

Lake Koshkonong, lying mainly in Jefferson County, is an enlargement of Rock River, its surface area covering about 30 square miles, the drainage area, or watershed, being about 2,540 square miles, including the area of watershed above it. There exists a low dam at Indian Ford, a few miles below, owned by Janesville manufacturers. A dam 20 feet in height could be constructed in this vicinity, to control the lake, but the claims for damage from overflow and flowing out mill privileges above would probably be so great as to preclude the idea of the government establishing one.

Lakes Mendota and Menona contain about 25 square miles of area, with a large drainage ground, but as their situations encircle the city of Madison the probability is that land damage from overflow would be very great.

Assistant Frizell estimates, from careful study, that above Janesville about 50,000,000 cubic feet of water might be impounded in the course of one year, and that for one hundred days about 5,700 cubic feet of water per second could possibly be drawn off to add to the low-water discharge of the Mississippi River below Rock Island. This would be, no doubt, of benefit to the Mississippi at time of extreme low-water, but the total deprivation to the mills during the time necessary to impound such a quantity of water would not only embarrass the mill-owners, but give rise to heavy claims.

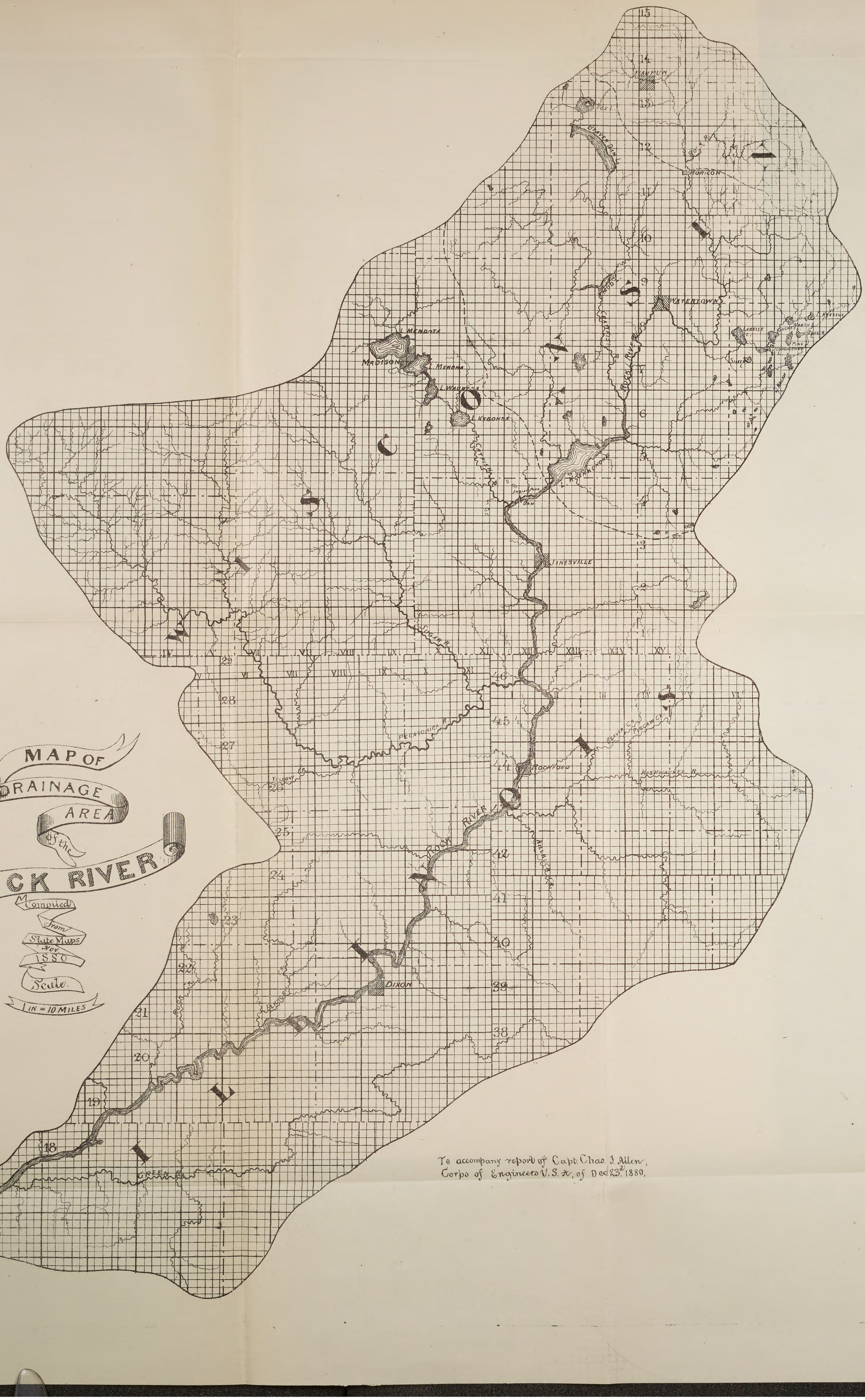
There are, at present, dams constructed across the river at many points, especially at Hustisford, Watertown, Jefferson, Indian Ford, Janesville, Beloit, Rockton, Rockford, Dixon, Sterling, and Milan—the latter near the confluence of the Rock and Mississippi Rivers. Some of the mill privileges in the lower part of the river might be enhanced in value by an equable flow of water throughout the greater part of the year; others above might be injured.

In General Warren's report upon bridging the Mississippi River, the area of the watershed of the Rock River is placed at 10,690 square miles, nearly equal in area to the watershed of the Wisconsin River.

MAP OF DRAINAGE AREA of the ROCK RIVER

Compiled from State Maps Nov. 1880

Scale. 1 IN = 10 MILES



To accompany report of Capt. Chas. J. Allen, Corps of Engineers U. S. A., of Dec. 23d. 1880.

	Feet.
Water surface, Mud Lake, September 17, 1879	1,554.452
Bench mark on hackmatack root at Mud Lake, north of Portage trail from Tomahawk Lake to Mud Lake	1,559.510
Water surface in Squirrel Lake, September 27, 1879	1,543.951
Bench mark on small pine tree, north end of Squrirel Lake	1,550.045
Water surface in Island Lake, September 9, 1879	1,561.508
Water surface in Tomahawk Lake, September 3, 1879	1,562.185
Bench mark at proposed dam-site on Tomahawk River, on right bank	1,566.980
Water surface on Kauquesagon Lake, September 9, 1879	1,561.208
Bench mark, Norway-pine root, Kauquesagon Lake, 200 feet east of Portage trail from Kauquesagon Lake to Tomahawk Lake	1,567.618
Water surface in Lake Sarah, September, 1879	1,574.539
Bench mark, root of white pine, 26 inches in diameter, at south end of Lake Sarah	1,583.211

W 11.

SURVEY OF SNAKE RIVER, MINNESOTA.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 28, 1880.

GENERAL: I have the honor to render the following report upon the survey of the Snake River, in Minnesota, made in pursuance of section 2, river and harbor act of Congress approved June 14, 1880.

The charge of the survey was intrusted to Assistant Engineer Frederick Terry, who commenced on the 11th of August and completed it by the 5th of October following.

The survey commenced at what is known as the Chengwatana Dam, about 2 miles below Pine City, and was carried up to Brunswick, a distance of about 20 miles. A gauge-rod was set at Chengwatana, its zero placed at the level of the floor of the most southerly sluice of the dam existing at this point, a dam built for the purpose of running logs into the Saint Croix, which latter stream receives the volume of the Snake River about 9 miles below Chengwatana.

The Snake River, for the 9 miles just mentioned, is a rapid torrent rushing between steep banks and entirely unsusceptible of navigation, excepting at enormous cost of improvement, if such improvement be not totally impracticable. The fall over this 9 miles is about 130 feet.

The survey from Chengwatana to Brunswick consisted of a transit line with stadia to measure distances between banks, &c., a careful line of levels and frequent soundings, the soundings plotted without reduction to low-water, the latter being a difficult plane to fix for the first 10 or 12 miles on account of the operations of various sluicing dams on the tributaries to the main river, as well as of the dam at Chengwatana, although the latter was closed as a general thing during the progress of the survey, giving a head of 3.1 to 4.9 feet.

This dam, producing above it a maximum head of about 9½ feet of water, ponds the river back for some 16 or more miles.

The closure of the gates accounts for the small slope, ascertained by levels during the survey, for 10 to 12 miles above it.

Snake River, between Pine City and Pokegama Flats, 4 miles above, had an average width of 600 feet at the time the party traversed it; the banks being low, a slight rise or fall of water surface is followed by rapid increase or diminution of width. The stream at Pokegama Flats spreads out for about 2½ miles, over a low marshy country, to a width

of about a mile, through which flows a tortuous channel, but one of good depth.

Between the flats and Brunswick, a distance of about 14 miles, the river narrows, averaging about 150 feet in width; the banks being, generally, 3 to 4 feet in height, are not liable to overflow, excepting during high-water, or when the head of water above the Chengwatana Dam is at its maximum.

Assistant Terry reports the difference of level at low-water between Millet's Rapids, 18 miles above the Chengwatana Dam, and the zero of the gauge established by him, to be 12 feet; and that, when the water is raised to the full height to which the dam is capable of raising it, the slope of water surface is about 2½ feet over the entire distance.

For the first 11 miles above Pine City (at which point the Saint Paul and Duluth Railroad crosses the Snake River by means of a low bridge) there is no need of any improvement, there being at ordinarily low-water a ruling depth of 3 feet in the channel. From the termination of this latter distance to Millet's Rapids, 5 miles further up stream, there is a number of bowlders of various sizes scattered through the channel, which will have to be removed if it be determined to make any improvement upon this stream. Two miles below Millet's Rapids, Rice Creek enters from the south. This creek is about 75 feet in width, and about 9 miles in length. The entrance to it, for about 1,000 feet, is of much less width than that of the creek above. During the past year parties interested in navigating the river and creek cut a small channel connecting the river and creek, but failed to make the cut of sufficient capacity, both as to width and depth.

The stage of water in the creek depends almost entirely upon that of the Snake River, to which it is tributary. For some distance above its mouth it is grown up with grass, rushes, &c.

The principal tributaries to the Snake River are the Knife, Ann, and Ground-House rivers on the right bank, and the Little Snake and Pokegama rivers on the left bank. The general course of the Snake River below Brunswick is from west to east.

The business upon the Snake River consists almost entirely in the driving of logs. But little farming is carried on, either in the vicinity of this stream or of Rice Creek. Two small steamers ply upon these streams, carrying supplies, &c.

* * * * * * *

Assistant Terry submits estimates of the cost of improving Snake River and Rice Creek; but as the act of Congress simply refers to the Snake River, I have only considered his estimate for that stream, viz, for removing bowlders from the channel, $3,400. My experience teaches me, however, that this is probably too low, as a crane boat, with strong iron grapples, would have to be provided for raising the bowlders and removing snags where necessary; also, a scow and floating accommodations and outfit for the shelter and subsistence of the workmen. I should place the cost at not less than $5,000. I will add, in connection, that I know of no public interest to be subserved by such expenditure.

I inclose herewith the report of Assistant Terry from which the information above given has been mostly obtained. Tracing from map of the survey will be forwarded as soon as completed.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The Snake River is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenues collected for the fiscal year ending June 30, 1880, amounted to $4,964.51.

There are two small steamboats on this river: one 60 feet long, 14 feet wide, about 3 feet draught, built in 1879; the other 110 feet long, 20 feet wide, and 16 inches draught, built in 1880. These boats ply between Brunswick, Minn. (population 300), and Pine City, Minn. (population about 700), a distance of about 18 miles, though at high stage of water they can go up Rice Creek, some 16 miles from Pine City, and up Pokegama Lake, about 12 miles from Pine City. In 1879 they made about twenty-five trips, carrying in all about 150 tons. The country tributary to the Snake is not densely settled, there being only about 4,500 people within a radius of 20 miles, so that the carrying trade at present is comparatively light and consequently not a profitable business.

It is claimed that in case the necessary improvements are made steamboating will be a great convenience and benefit to the settlers by putting them in direct communication with the railroad, thus affording them a market for their products and facilities for getting their hard wood and timber to market and obtaining their supplies without making long journeys over poor roads.

The steamboats next season will have, probably, plenty to do in the way of towing logs, ties, piles, wood, &c. During the season of 1880 there will run down Snake River 75,000,000 of feet of logs, 4,000 railroad ties, and 100,000 linear feet of piles, valued at $530,000. It is expected that a larger quantity than the above will be run down in 1881.

REPORT OF MR. FREDERICK TERRY, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 27, 1880.

SIR: I respectfully submit the following report of the survey of a portion of the Snake River during the past season:

In obedience to your instructions, I left Saint Paul on August 10 and proceeded to Pine City, Minn. I commenced the survey at Chengwatana Dam, about 2 miles below Pine City, and carried it up to Brunswick, a distance of about 20 miles. This work was completed on September 7.

The party was then divided into two leveling parties; one party, under Mr. John Cullen, carrying the levels from Chengwatana Dam down Snake River to the Saint Croix River, thence down the Saint Croix River to Taylor's Falls, connecting at that point with the levels that were carried from Taylor's Falls to Prescott in 1879; the other party, under my personal charge, carried the levels from a bench mark on the Snake River, about 1½ miles below the mouth of Knife River, to Mille-Lacs. The bench mark from which I started was established by Mr. Vine D. Simar, assistant engineer, in 1879, by a line of levels from Grass Lake. I had, during the progress of the detailed survey of Snake River, connected the bench mark at Grass Lake with a bench mark at Chengwatana Dam, so that on the completion of the work of the two leveling parties, which was accomplished on October 5, the water surface of Mille-Lacs was connected with the levels of the Mississippi River system. I give below a table showing the heights of points, assuming Lake Superior to be 602 feet, and the zero of the Saint Paul gauge to be 678 feet above sea-level:

	Feet.
Zero of gauge at Taylor's Falls	679.158
Low-water, mouth of Snake River	791.769
Bottom of sluice-gate, Chengwatana Dam	924.027
Water surface, Mille-Lacs	1,246.179

I found high-water marks on trees at Mille-Lacs, which make the high-water of 1880 1,248.719 feet above sea-level. This is probably as high as the water has been for a number of years, and, from information derived there, I should judge the low-water of 1878 to have been 2½ feet below the stage I found the lake at; this would give a range of about 5 feet between high and low-water.

Snake River, between Pine City and Pokegama Flats, a distance of 4 miles, averages about 600 feet in width at the stage of water during which the survey was made, namely, about 4 feet; but, as the banks are low, the width changes very much with the rise and fall of the water. At Pokegama Flats the river, for about 2½ miles, spreads out over a low, marshy country to a width of about 1 mile, through which winds a very crooked channel of good depth. Between the flats and Brunswick, a distance of about 13½ miles, the river becomes much narrower, averaging about 150

feet in width, and, as the banks are generally 3 or 4 feet in height, the width does not vary, except during the spring rise.

The stage of water in the river is controlled, in great part, by a system of dams erected by the lumbermen on the Snake and its tributaries. The largest of these is the Chengwatana Dam, which is built across the Snake River, 1½ miles below Pine City, and is capable of retaining a head of 9½ feet. The slope of the river at low-water, assuming the bottom of the sluice-gates at Chengwatana Dam as low-water, is 12 feet from the foot of Millet's Rapids down to the dam; with a full head on the dam, the slope would be 2½ feet. The dams on the Snake River and its tributaries are open in the spring, and generally remain open until late in the autumn, with the exception of Chengwatana Dam, which remains closed during most of the year; this management of the dams is the best that can be devised for the navigable portion of the river.

In proceeding up the river from Pine City, for the first 13 miles there is no need of any work being done, as there is during the ordinary stage of water a depth of at least 3 feet in the channel. From this point to Millet's Rapids, a distance of 5 miles, there is a large number of bowlders scattered through the channel which will have to be removed to make navigation safe. Two miles below Millet's Rapids, Rice Creek enters from the south. This creek is about 75 feet in width, and about 9 miles in length. It has a very narrow entrance, but about 1,000 feet above its mouth it widens out, and also turns to the north until it approaches within about 40 feet of the Snake River. During the past season parties interested in the steamboats on the river cut a channel across the narrow neck of land separating the two streams, which would have made a better entrance if it had been taken out deep enough, but it needs to be deepened 2 feet. For the first ½ mile above the "cut-off" the creek is full of grass, and will have to be cleaned out before it can become navigable at the usual stage of the river. The slope of Rice Creek is so very slight that there is no perceptible current, and its stage of water is almost entirely dependent upon the backwater from Snake River. With the improvements I have suggested, and the usual head of water on Chengwatana Dam, I think Rice Creek could be made navigable for small boats drawing not over 3 feet of water for a distance of 5 miles, thus giving access to a farming region that has no present outlet except by wagon.

I give below an estimate of the probable expense of improving Snake River and Rice Creek, and would state at the same time that I can see no reason for making the expenditure, as there is at present no business on the river that would make the running of boats profitable, and there will not be until the country becomes more thickly settled.

For removing bowlders from the channel of Snake River	$3,400
For deepening the entrance to Rice Creek, removing rushes, &c	1,600
Total	5,000

Very respectfully, your obedient servant,

FREDERICK TERRY,
Assistant Engineer.

Capt. CHARLES J. ALLEN,
Corps of Engineers, U. S. A.

W 12.

EXAMINATION OF UPPER RED RIVER OF THE NORTH, BETWEEN FARGO DAKOTA, AND BRECKINRIDGE, MINNESOTA.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 31, 1880.

GENERAL: I have the honor to render the following report upon the examination of the Red River of the North, between Fargo, Dak. (Moorhead, Minn., is on the right bank and directly opposite), and Breckinridge, Minn., in accordance with the requirements of section 2, river and harbor act, approved June 14, 1880.

The examination was intrusted to Mr. Charles Wanzer, assistant engineer, in local charge of the work of improvement upon the Red River. He took the field, with a small party, on the 14th of September last, and

completed the field-work on the 9th of October following. The examination consisted of channel and cross-section soundings for the entire distance, and a check line of levels for the purpose of ascertaining the slopes of the river.

This portion of the river received very complete and accurate survey in 1874, by Major Farquhar, Corps of Engineers, the maps of which are on file in this office.

The principal aim of the examination this past season was to ascertain whether or not changes of any importance had occurred in the bed of the stream since 1874. The stages of water in 1874 and 1880 not being exactly the same, an exact concordance between slopes and channel distances for those years could not be expected; yet the difference was found to be so slight that the examination last season is practically a confirmation of the correctness of the survey of 1874.

Assistant Wanzer reports:

In accordance with your instructions, I started on September 14 to make an examination of this portion of the river. The examination consisted of channel and cross-section soundings for the entire distance, and a check line of levels for the purpose of ascertaining the river slopes. From Breckinridge (the junction of the Otter Tail and Bois de Sioux rivers) to old Fort Abercrombie—a distance, by river, of 26 miles—the slope or fall of the surface of the stream is 35.542 feet, or an average slope per mile of 1.36 feet, with one stretch included of 1.3 miles with an average slope of 2.86 feet per mile. This latter slope is over what is known as Conolly's Rapids. The river for the entire 26 miles is about 200 feet wide, and for a greater portion of the distance the river bed is formed of gravel, mixed with frequent bowlders, some of which have cubical contents of 5 yards. Soundings show, in eleven different stretches of river, a low-water channel of less than 1 foot. These are not isolated soundings, but continue for distances of from 1 to 500 feet, and even for these depths of channel are very narrow and tortuous and completely hemmed in by large bowlders. No improvements can reasonably be made over this entire portion of the river, without furnishing slack-water navigation by means of locks and dams. As there seems to be no commercial demand for any such extensive improvements as would be required, I have made no estimates of their cost. Fort Abercrombie should be considered the head of navigation on the Red River of the North; the portion of river between that point and Breckinridge being possible for navigation for a few days only in the year, during the period of extreme high-water.

From Fort Abercrombie to Fargo the distance, by river, is 75.6 miles, with an average slope per mile of a little over 0.5 of a foot. During the winter of 1879 and 1880 a party, under your authority, cut down the overhanging trees and removed all snags which were to be found, while the river was frozen. The work was well done as far as it was possible to do, but during the period of open river and low-water a considerable number of dangerous snags are still to be seen, and should be removed. This work could be done during the first low-water period of the coming season.

The river, from Fort Abercrombie to Fargo, is naturally superior for navigable purposes to that part of the stream from Fargo to the mouth of the Cheyenne River, 20 miles below Fargo, and very little work will be required to perfect it. To within 6 miles of Fargo nothing is required but the removal of snags, but over the latter 6 miles mentioned about 40,000 yards of earth will have to be removed by dredging. The removal of snags is by far the more needed improvement at present, and should, if possible, be accomplished first. It is anticipated that a regular line of boats will run over this portion of the river during the coming season for the purpose of carrying wheat to the two railways now touching the river at Fargo.

* * * * * * *

Gaugings of the upper river 19 miles above Moorhead (just below the mouth of the Wild Rice River) show the discharge, on September 9, to be 895.42 cubic feet; low-water discharge to be 465.9 cubic feet per second. The total cost of the examination was $333, and was completed October 9, 1880.

* * * * * * *

The river was open and free of ice for a period of 214 days in 1880.

It will be seen from the above that Assistant Wanzer does not consider the stretch of 26 miles of river between Breckinridge and Fort Abercrombie (the former at the junction of the Otter Tail and Bois de Sioux rivers) as susceptible of thorough improvement at low-water stage, excepting at great expense, the low-water slope of the stream be-

tween the points named being at the time of the survey 35.5 feet, or an average of 1.36 feet to the mile, and the bed of the river composed mostly of gravel and granite bowlders, some of the latter having contents of five cubic yards. The water upon the principal shoal, within this stretch of river, known as Conolly's Rapids, has an average slope of 2.86 feet for a distance of 1.3 miles. There is little commerce between Breckinridge and Fort Abercrombie. Light-draught flats and barges are built at Breckinridge and floated down, unloaded, to Abercrombie, Fargo, and other points, where they are used for the transportation of wheat, &c.

Between Fort Abercrombrie and Fargo, a distance of 75.6 miles, by river, the slope per mile averages a little more than half a foot.

During the winter of 1879 and 1880, a number of snags and leaning trees were removed from the river, between the two last named points, the party moving on the ice. The cost of this work was about $3,000. This secured a safe high-water channel, but a number of dangerous snags which could not be discovered through the ice still remain. These and a number still of overhanging trees should be removed, in order to render the stream at low-water navigable. The result of the winter's work was apparent last season, when about 120,000 bushels of wheat were boated down the stream to Fargo. To within 6 miles of Fargo nothing further than the removal of snags and trees seems to be needed, but over the last mentioned stretch (6 miles) about 40,000 cubic yards of material require removal by dredging. The United States dredge, during the past season, excavated and removed the tough clay of the river bed at a cost of $12\frac{2}{3}$ cents per cubic yard.

As the cost of operating the dredge may increase during the next year or two, on account of increase in price of labor and fuel, the cost of dredging and removal of the spoil may be set at about 16 cents per yard, or $6,400 for the dredging.

The Northern Pacific Railroad bridge, crossing the Red River from Moorehead to Fargo, completely bars the ascent of steamers, it being unprovided with a draw, its lower chord about 14 inches above extreme high-water, and about 29 feet above extreme low-water. During high-water it is a bar even to the passage of flats and barges.

A wagon bridge, built upon light trestles, also spans the river a few feet below the railroad bridge. In order to move the United States dredge to the point requiring excavation above Fargo, a portion of the wagon bridge would have to be removed and replaced; this, however, could be done at little expense. But, in order to pass the railroad bridge at any stage of water, the "A" braces and cross-braces of the dredge—the former of which rise to a height of about 48 feet above the deck, or about 52 feet above the water surface—must be taken down. After passing the bridge the braces and boom would have to be set up again. Upon completion of the dredging, which would require the dredge to work to its full capacity for an entire working season, the operation of removal and replacing would have to be repeated. The cost of such, if no accident should occur in lowering and raising such heavy framings of timber, would not exceed, probably, a few hundreds of dollars; but there remains the risk of accident. The question arises whether the United States Government should not require the railroad bridge to be provided with a draw, as are all the bridges spanning the Red River below this point.

It would not be advisable to withdraw the United States dredge from its present work below Fargo for at least another season; although this would depend upon the stage of water during the late summer and the

fall months. Major Farquhar rendered an estimate for the improvement of the stretch of river under consideration, in his report to the Chief of Engineers February 8, 1875. The cost he placed at $22,663.98, including 10 per cent. for contingencies. This estimate is believed to be about correct. In my annual report for the fiscal year ending June 30, 1880, I estimated $10,000 as the sum that could be profitably expended above Fargo during the fiscal year ending June 30, 1882, and the results of the examination confirm the correctness of that estimate.

The surface of water was about 1 foot above low-water during the time of the examination.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The Red River of the North is in the collection district of Minnesota, of which Pembina is the port of entry. The district of Minnesota, however, embraces all of the State of Minnesota (except the waters of Lake Superior) and all of Dakota Territory; with deputy collectors at Saint Paul and Saint Vincent, Minn., and Bismarck, Dak. The amount of revenue (duties and fees) collected at Pembina and Saint Vincent during the fiscal year ending June 30, 1880, was $16,554.35.

Commerce of the Red River of the North between Abercrombie, Dak. (just below Breckinridge, Minn.), and Fargo, Dak., for 1880: Shipped from Abercrombie to Fargo, by steamboat and barges, 1,529,220 pounds wheat; by flat-boats and rafts, 7,200,000 pounds wood; total, $8,729,220.

Considering the scant shipping facilities, the above amount is not regarded as small and represents but a portion of the business that may be expected in case the river is cleared of snags and other obstructions sufficiently to warrant the risk of placing additional steamboats and barges upon it. Yet, it is stated upon good authority that a new line of boats will be put on next season to ply between the points named to carry wheat to the railroad, there being at present 250,000 bushels directly tributary to the river between Breckinridge and Fargo. Wheat-raising and general farming is the principal interest in the Red River Valley.

Railroads cross the river at Breckinridge, Moorhead, and Grand Forks.

W 13.

EXAMINATION OF MINNESOTA RIVER NEAR THE VILLAGE OF BELLE PLAIN, MINNESOTA.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., December 23, 1880.

GENERAL: I have the honor to render the following report upon the examination of the narrow neck of land opposite the village of Belle Plain, upon the Minnesota River, made in accordance with the requirements of section 2, river and harbor act of Congress approved June 14, 1880, the pertaining paragraph reading as follows:

> Minnesota River, near the village of Belle Plain, with a view to prevent the breaking away of the banks of the narrow neck of land opposite said village, and injury to the navigation of said river in Minnesota.

The examination was made by Assistant Frederick Terry during the latter part of October.

Belle Plain is a village of about 750 inhabitants, situated upon the left bank of the Minnesota River.

In 1879 the citizens built a wagon bridge, with a draw, across the river, at a cost of about $20,000. The bridge is useful, probably as much to the farmers of the vicinity as to the citizens of Belle Plain. The road leading from the north end of the bridge passes through a narrow neck of land—(please see sketch herewith)—where the least width between banks is about 200 feet. This neck, Assistant Terry reports, is cutting away, on the right bank, at the rate of about 5 feet a year, the erosion having progressed to within about 30 feet of the wagon road. The fear upon the part of those interested in the preservation of this approach to the bridge seems to be that the stream may break through the neck of land and leave the bridge abutting upon an island.

Assistant Terry presents two plans, with estimates of the cost, of protecting 900 linear feet of bank in the bend.

The first contemplates carrying the protection up to the top of the bank, which is about 25 feet above low-water. The cost he places at $9,900.

The second plan proposed by him is to carry the protection up to 10 feet above low-water. The cost he places at $5,000.

I inclose herewith the report of Assistant Terry; also, sketch of the locality.*

The Minnesota River is not navigated above Carver—the latter about 19 miles below Belle Plain; and below Carver the navigation practically amounts to nothing.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

STATISTICS.

Belle Plain is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenues collected during the fiscal year ending June 30, 1880, amounted to $4,964.51. There are no commercial statistics to report.

The commerce of the river, even before the advent of the railroad through the Minnesota River Valley, was not large in any one season, and since that time only an occasional small wild packet has ascended the river.

In May, 1876, two steamboats that went up the river during high-water had to discharge their return freight at Mankato before they could return to the Mississippi River, owing to the great number of snags and other obstructions.

W 14.

SURVEY OF THE MISSISSIPPI RIVER AT SAUK RAPIDS, NEAR THE CITY OF SAINT CLOUD, MINN.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., February 8, 1881.

GENERAL: I have the honor to render the following report upon the survey of the "Mississippi River, at Sauk Rapids, near the city of Saint

* Omitted. Printed in House Ex. Doc. No. 22, Forty-sixth Congress, third session.

Cloud, Minnesota," made in accordance with the terms of the leading paragraph of section 2, river and harbor act of Congress, approved June 14, 1880—

That the Secretary of War is hereby directed, at his discretion, to cause examinations of surveys, or both, and estimates of cost of improvements proper to be made.

* * * * * * *

The survey, with which Assistant Frederick Terry was charged, practically commenced on the 11th of October last, and was continued until the 27th of October, 1880, when the party returned, the work having, to that date, been only partially completed for reasons to be stated further on.

The survey covered about 4 linear miles of river, commencing at a point near the existing dam at Sauk Rapids, thence extending down stream to the head of the Thousand Islands, the latter about 1.6 miles below Saint Cloud.

The work consisted of a carefully checked line of levels along the shore, the elevations of water-surface being taken about every 650 feet, the meanders by transit, and the widths by stadia. No soundings were taken, as those made during the very complete survey in 1874 by my predecessor, and referred to low-water of the Saint Paul gauge, could be utilized on account of the hardness of the bed of the stream. Besides, with the funds and appliances at command, it would have been too expensive to have undertaken such at the time of our survey last fall.

The discharge of the river was gauged October 26, and the volume computed at 4,135 cubic feet per second, the stand of water on the Saint Paul gauge being at that date 2.2 feet above low-water of 1864.

Assistant Terry reports that since the survey of 1874 no natural changes of importance have occurred, and the only artificial one of importance the completion by the Sauk Rapids Water-Power Company of their dam across the river. This dam he reports as built of crib-work filled with stone and in bad condition.

The report of Assistant Terry is herewith inclosed.*

In January following Assistant Terry returned and made enough soundings through the ice to verify the utility of those of 1874. A party skilled in boring operations was engaged at the same time to make borings in order to ascertain the nature of the bed of the stream. Although not as many were taken as I should have desired, yet there were enough to enable approximate estimates of cost to be made.

Major Farquhar in his report of February 8, 1875, presents three projects for passing boats over Sauk Rapids, as follows:

To build a masonry dam over that part of the river not already dammed at Sauk Rapids, and to make a canal in the upper level along the west bank down as far as the old steamboat landing at Saint Cloud. At the lower end of the canal a lock with a chamber 50 feet by 200 feet and 17 feet lift is to be constructed; the canal to have a least width of 100 feet at the water-line, and a least depth of 5 feet, and to be 5,000 feet long, the entrance to the canal to be protected by guard-gates.

This improvement will cost as follows:

If the lock-chamber sides are of hammered masonry, backed with rubble-masonry, iron gates, and crib-dam	$647,000
Same, concrete in place of rubble-masonry	520,000
Same, concrete side walls protected with wooden fenders except in hollow quoins and gate-recesses, where dressed stone will be used	464,000†

Assistant J. P. Frizell took personal charge of the operations in January; his report is herewith.

He presents two projects:

First, to construct a lateral canal along the right bank from a point

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* Omitted. Printed in Senate Ex. Doc. No. 51, 46th Congress, third session.

† Dredging not here included.—C. J. A.

about 1,100 feet above the uppermost branch of the present dam (please see tracing accompanying) to a point about 6,000 feet below; the entire length of the canal to be 8,100 feet; to be 100 feet wide at bottom, with banks sloping about 1 on 1½. Banks to be protected by riprapping, &c. The canal to have a lock at the lower end of about 15 feet lift and a guard-and-lift lock near the existing dam; the canal to pass boats of 200 feet length and 5 feet draught. The river below the site of the proposed lower lock falls at the rate of 1 in 1,000 for nearly a mile. Some dredging would be required of the bowlders and gravel for a 5-foot navigation at low-water. The total cost of this first project is placed at $801,939.75.

The second project presented consists in the erection of a new dam, to be located about 14,500 feet below the existing dam at Sauk Rapids. This proposed dam to be 25 feet in height above ordinary low-water, and to be provided with flash-boards so as to raise the water 4 feet to 6 feet higher whenever desirable to do so. The dam to be about 1,200 feet long, on top; the greatest height above the base to be about 45 feet, and thickness of base about 32 feet. The dam to be flanked by a short canal with locks on the left bank. The cost of this project is placed at $655,764.75. Some dredging will be required.

Commenting upon this second project, Mr. Frizell says:

> The establishments at the existing dam consist of one grist-mill and one elevator, both wooden buildings. Reparation for the injury would consist in transmitting power from the new dam by wire rope or other means, or in removing the establishments and machinery to the new dam. In either case it is believed that $100,000 would amply cover all legitimate claims. The work being in the immediate vicinity of extensive quarries, we are able to adopt a low figure for masonry. An immense and prospectively very valuable water-power will be developed by the execution of the second project. Should an appropriation be made for rendering the river navigable at this point, it is quite probable that responsible parties would undertake the construction of these works at a much lower price than is named above in consideration of the benefits accruing from the water-power.

The survey was made strictly in accordance with the terms of the act of Congress ordering it.

From the site of the proposed new dam to Minneapolis the least cost of securing a 5-foot low-water channel was estimated in the report of February 8, above alluded to, at $144,667.50, and of securing a 3-foot low-water channel between the same points, $75,390, the cost of passing boats over Sauk Rapids being *in addition* to either item.

If the 3-foot channel plan were the only one to be adopted, diminution in cost of locks, canal, and the stretch of dredging mentioned in the vicinity of Saint Cloud and Sauk Rapids would ensue. Still, the cost of either of the projects presented would be heavy.

About $18,000 were expended upon the river between Minneapolis and Saint Cloud from 1876 to 1880. The work under the appropriation consisted in dredging and building of wing-dams, closing of chutes, &c. Many of the latter works were purposely destroyed by loggers in order to pass their logs through the chutes, they preferring such course in violation of law rather than to take the trouble to sheer them into the regular channels. Efforts to apprehend the depredators failed. Some of the dams erected at the Thousand Islands by my predecessor in charge were thus damaged. The breaches were repaired, only to be reopened. Other dams below were also broken through.

The steamboat navigation between Minneapolis and Sauk Rapids (the latter about 3 miles above Saint Cloud) is very light, and from Sauk Rapids to Brainerd no steamers are known to run. The cost of improve-

ment of the river above Sauk Rapids was also estimated in the report of 1875 referred to.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

STATISTICS.

Saint Cloud and Sauk Rapids, Minn., are in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenues collected for the fiscal year ending June 30, 1880, amounted to $4,964.51.

Since 1878 there has been no use made of the river between Minneapolis and Saint Cloud for any purposes of commerce except the running of logs.

In that year but one steamboat plied on the river above the Falls of Saint Anthony between the points named. She made only 30 trips (6 to Clearwater, 24 to Saint Cloud), carrying up stream merchandise and machinery amounting to 375 tons, and bringing down stream live stock, wheat, potatoes, &c.; also, 6 barges hoop-poles, 600 cords wood, and 200,000 feet, B. M., lumber. Passengers carried, about 600.

In the years 1855, 1856, 1857, 1858, and 1859, before the railroad was built, steamboats were run between Minneapolis and Saint Cloud during high-water, as high as four being engaged in the trade at one time. There is no record, however, of the amount of business done.

The logs run down the river between Minneapolis and Sauk Rapids during season of 1879 amounted to 132,000,000 feet, valued at $924,000. During 1880 the amount of logs run was 149,000,000 feet, valued at $1,192,000.

Sauk Rapids water power, estimated at 12,000 horse-power, partly developed. Saint Cloud water-power estimated at 12,000 horse-power. At the former place flour only is manufactured; 16,000 barrels manufactured each year, valued at $90,000. At Saint Cloud lumber manufactured amounted to 4,000,000 feet, B. M.; lath manufactured 650,000 feet, B. M.; shingles manufactured, 3,600,000; total valued at $70,000.

REPORT OF MR. JOSEPH P. FRIZELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., January 29, 1881.

SIR: The river and harbor act approved June 14, 1880, requires a survey of the Mississippi River at Sauk Rapids, near the city of Saint Cloud, Minn., with estimate of cost of improvements proper to be made.

A survey of this locality was made in 1874, under direction of Maj. F. U. Farquhar. It was made with reference to the improvement of navigation, and was sufficiently complete as regards topography. The project of improvement submitted by Major Farquhar consisted in a canal leading from the water-power dam, near the head of the rapids, down to what is known as the old steamboat landing, that being the highest point accessible by boats. The canal was to have 5 feet depth of water, a lock of 17 feet lift (50 feet by 200 feet at the lower end), and a guard *gate* at the entrance. It involved the reconstruction and maintenance of the existing water-power dam by the United States. The cost of the necessary works of the most permanent construction was put at $647,000. This was given as an approximation, as the survey did not include any examination of the ground below the surface.

Assistant F. Terry was sent to Sauk Rapids late in the past season in execution of the survey above referred to. He repeated the survey of 1874 to a sufficient extent to determine that no material revision of that survey was necessary, and that no great natural changes had occurred in the mean time. The borings, the most important part of the work, were deferred till the closing of the river by ice.

In January Mr. Terry returned, and made soundings through the ice as far as the river had closed, and a party skilled in such operations was set to work driving pipes in the manner of drive-wells to ascertain the nature of the bottom. This work was stopped by your order, before its completion, so that we are still without the means of making a sufficiently accurate estimate of the cost of the proper improvements. The total excavation can be computed with sufficient accuracy, but the canal will be partly in

rock-cutting, the precise amount of which will be, to some extent, a matter of conjecture.

The following estimate is based upon a project having the same general features as proposed by Colonel Farquhar, with this exception, that to avoid the complication and embarrassment likely to result from the incorporation of private works into the scheme of improvement, the canal is supposed to extend above the water-power dam far enough to be accessible without reference to the same. This will make its length about 8,100 feet. It will be 100 feet wide on bottom, slopes 1½ on 1. A lock of about 15 feet lift at the lower end, and a guard-and-lift lock at the entrance, or as near the same as rock foundation can be got. All designed for boats of 200 feet length and 5 feet draught. The river below the lower lock falls at the rate of 1 foot in 1,000 for nearly a mile, and would require some dredging and removal of bowlders for a 5-foot navigation. As an alternative plan, I give the cost of a high dam, with suitable locks, near the foot of the rapids flowing out the water-power dam, and, of course, involving suitable compensation to injured parties.

For the purpose of this estimate a line of borings or perforations executed as above was made across the river at a point near the Normal School, about 15,000 feet below the water-power dam. Rock was encountered under the east half of the river, rising to the surface at the east shore. On the west half the borings terminated in an impenetrable clay, which is usually found immediately overlying the rock. The borings did not extend far enough east to cover the site of the dam, the ground rising gently on that side, but as rock crops out not far distant it will probably be met with at no great depth.

On the line of the canal the borings commenced at the site of the lower lock, and extended a distance of 2,000 feet up stream. They reached to a depth of 10 to 20 feet, and all terminated in the same impenetrable clay. Further up rock appears in place. From the narrowness and rapidity of the stream the canal cannot encroach much upon the river bed, but must be largely in excavation, and the steepness and height of the bank make the cutting very heavy. The approximate cost will be as follows:

450,000 cubic yards excavation (150,000 placed in embankment and the remainder wasted), at 40 cents	$180,000 00
80,000 cubic yards (probably) rock, excavated and placed in riprap and pavement of slopes, at $2.50	200,000 00
Coffer-dams, bailing and draining	20,000 00
Land damages	10,000 00
Contingencies, 10 per cent	41,000 00
Engineering, 5 per cent	22,550 00
Total cost of canal	473,550 00

LOWER LOCK.

600 linear feet of coffer-dam, at $5.50	$3,300 00
7,500 cubic yards excavation, at 50 cents	3,750 00
Pumping, 100 days, at $15	1,500 00
1,600 cubic yards face and coping stone, at $15	24,000 00
5,600 cubic yards rubble masonry, at $8	44,800 00
600 cubic yards masonry in breast and miter walls, at $10	6,000 00
Extra cutting in quoins and miter sills	1,500 00
Timber, 150 M, at $50, in place	7,500 00
Iron, 50,000 pounds, at 6 cents, in place	3,000 00
Contingencies, 10 per cent	9,535 00
Engineering, 5 per cent	5,244 25
Total	110,129 25

UPPER LOCK.

600 linear feet coffer-dam, at $5.50	$3,300 00
Pumping	1,500 00
1,300 cubic yards face and coping, at $15	19,500 00
2,900 cubic yards rubble backing, at $8	23,200 00
100 cubic yards in breast and miter walls, at $10	1,000 00
Extra cutting in hollow quoins and miter sills	1,200 00
Timber, 140 M, at $50, in place	7,000 00
Iron, 40,000 pounds, at 6 cents, in place	2,400 00
Contingencies, 10 per cent	5,910 00
Engineering, 5 per cent	3,250 50
Total	68,260 50

Total cost of upper lock	$68,260 50
Total cost of lower lock	110,129 25
Total cost of canal	473,550 00
Removal of 75,000 cubic yards cemented gravel and bowlder from bed of river, at $2 (probably more)	150,000 00
Total cost of first project	801,939 75

In the second project the dam is supposed to be 25 feet high above ordinary low-water, and provided with flush-boards, by which the water can be raised 4 or 5 feet higher when desirable. The dam to be about 1,200 feet long on the top. Its greatest height above the base will be about 45 feet and the base will be 32 feet thick at this point. The overflow will be some 800 feet long, and this part would rest on rock. The lock or locks will be on rock foundation largely in excavation, and the rock removed will all be available in the construction of the dam.

A line of stone-filled cribs across the river (half at a time) to create slack water for building the coffer-dams	$7,000 00
1,200 linear feet of coffer-dam, at $10	12,000 00
Pumping 200 days, at $25	5,000 00
24,000 cubic yards rubble-masonry backing, at $8	192,000 00
1,000 cubic yards masonry in mole above dam, at $10	10,000 00
1,500 cubic yards extra heavy cap-stones, at $25	37,500 00
2,800 cubic yards quarry-faced ashlar facing, at $15	42,000 00
65,000 cubic yards excavation, at 30 cents	19,500 00
15,000 cubic yards excavation, at 50 cents	7,500 00
Contingencies and engineering, 15 per cent	49,875 00
Locks, same as in first project	178,389 75
Land damages at sights of locks, say	5,000 00
Damage from flowing out existing dam	100,000 00
Total	665,764 75

The establishments at the existing dam consist of one grist-mill and one elevator, both wooden buildings. Reparation for the injury would consist in transmitting power from the new dam by wire rope or other means, or in removing the establishments and machinery to the new dam. In either case it is believed that $100,000 would amply cover all legitimate claims. The work being in the immediate vicinity of extensive quarries, we are able to adopt a low figure for masonry. An immense and prospectively very valuable water-power will be developed by the execution of the second project. Should an appropriation be made for rendering the river navigable at this point, it is quite probable that responsible parties would undertake the construction of these works at a much lower price than is named above, in consideration of the benefits accruing from the water-power.

Very respectfully, your obedient servant,

JOS. P. FRIZELL,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

APPENDIX X.

IMPROVEMENT OF TENNESSEE AND CUMBERLAND RIVERS AND OF RIVERS IN EASTERN TENNESSEE AND GEORGIA.

REPORT OF MAJOR WILLIAM R. KING, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., August 18, 1881.

GENERAL: I have the honor to submit annual reports on the works under my charge for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

CHIEF OF ENGINEERS, U. S. A.

X 1.

IMPROVEMENT OF TENNESSEE RIVER.

I. ABOVE CHATTANOOGA.

In 1830 a careful examination of the Holston and Tennessee rivers between Kingsport, Tenn., and the Alabama State line, was made by Col. S. H. Long, United States Topographical Engineers. This examination included the 189 miles between Knoxville and Chattanooga now designated "the Tennessee River above Chattanooga," and the report, which was reprinted in 1875, gives a detailed description of every obstruction to navigation, forty-three in number, at that time, and plans and estimates for their improvement.

In 1852 Congress appropriated $50,000 for the improvement of the navigation of the Tennessee River, and some of the dams built under this appropriation are still in existence though generally covered up by the more extensive work of recent improvement.

In 1871 the sum of $35,000 was made available from the appropriation for the improvement of Tennessee River, below Chattanooga, and with that and subsequent appropriations the work has been continued from year to year during the low-water season until the present time.

The bed and banks of this river are remarkably permanent and have been but little changed by the floods of the last fifty years as shown by the report and maps of Colonel Long's examination.

The obstructions consist of shoals of sand and gravel, reefs of rock, snags, &c., and the principal improvement consists in excavating a chan-

nel through the reefs and increasing the depth of water at the shoals by means of stone wing-dams so constructed as to narrow the channel and cause it to scour deeper or become deeper by the additional volume of water thrown into it.

The dams are generally made of heavy stone founded upon rock, and, not being subject to damage by ice as in most northern streams, they are practically permanent structures and the channel excavations seldom show signs of filling up.

The improvement when once completed will therefore require but little expense for repairs for many years to come. Some of the dams have already withstood the floods of eight or nine winters without serious damage. Most of the damage experienced has been traced to defective connections with the shore which has since been remedied, and to the wanton destruction caused by parties who make holes in them for the passage of small boats to save themselves a little distance in rowing.

Of the twenty-nine obstructions requiring improvement, twenty-one have been partially removed and others have been more or less improved.

The last season's work was chiefly directed to completing the dams at Chota, and Coulter's Shoals, and beginning that at Little River Shoals, which is next in order as a troublesome obstruction. Considerable work was also done at Half Moon Island in closing a gap formed by the river washing around the end of a dam.

The following quantities represent the several items of work done during the year:

	Cubic yards.
Stone quarried	2,480
Loose rock hauled to river bank (for dams)	441
Rock put in dams	2,473

The work is being done in a thorough, subtantial, and economical manner by hired labor under Assistant Engineer J. S. Crary. The working season extended over about eight months of the year, the daily average of force employed during that period being thirty-one men.

As stated in former reports, the small amount of the annual appropriations has caused the work to drag along for more than double the time it ought to have taken, and has added materially to the cost.

The following figures relating to "The Landing" at Chattanooga will give an idea of the amount of commerce on this part of the Tennessee River:

Number of steamboats running		8
Number of landings made at Chattanooga		625
Number of flat-boats		396
Freight, consisting of iron ore, limestone, coal, &c	tons..	70,355
Grain	bushels..	757,564
Hay	bales..	3,540
Lumber, including poplar, pine, gum, oak, and walnut	feet..	10,440,000

The following is a list of the steamboats and their registered tonnage now employed on the Upper Tennessee. Their carrying capacity is estimated to be one-fourth greater than the figures given:

	Tons.
1. R. M. Bishop	256
2. City of Knoxville	233
3. J. H. Johnson	240
4. Chattanooga	190
5. J. T. Wilder	185
6. M. H. Clift	85
7. H. C. Murray	50
8. R. R. Anderson	225

The importance of this improvement is enhanced by the fact that the Clinch and French Broad rivers, two of its largest tributaries, are being improved, and when the Muscle Shoals obstruction is removed so that steamers from the Ohio and other western rivers can ascend the Tennessee as far as Knoxville, it is probable that a more elaborate system of improvement, possibly involving locks and dams at some points, will be demanded by the commercial interests involved.

In its present condition the river is navigable during the greater part of the year, in fact there is hardly a month together in average years when the water is too low for the smaller boats to run as far up as Loudon, but the few remaining shoals should all be put in as good condition as the best of those already improved, and many of those now considered passable should be still further improved by blasting out more of the obstructing reefs in some cases, and in others by building additional dams or strengthening those already built.

The original estimate of the cost of this improvement was based upon a mere examination, and the more accurate soundings and other measurements that have since been taken, together with the experience gained in prosecuting the actual work of improvement, will furnish data for a revised estimate of the cost of completing the work in accordance with plans adapted to the increased demands of commerce.

This work is in the collection district of New Orleans. Ports of delivery at Chattanooga and Knoxville, Tenn.

The original estimate of cost was		$175,000 00
Which for reason given in 1877 was increased		50,000 00
Making estimate of cost of improving Tennessee River above Chattanooga		225,000 00
Amount appropriated		208,500 00
Amount expended		202,772 90

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	7,000 00	
		$17,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	9,495 46	
July 1, 1881, outstanding liabilities	1,777 44	
		11,272 90
July 1, 1881, amount available		5,727 10
Amount (estimated) required for completion of existing project		16,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		16,500 00

II.—BELOW CHATTANOOGA.

From Chattanooga to Paducah, a distance of 453 miles, the Tennessee River is now navigable, excepting for a distance of about 23 miles between Florence and Decatur, Ala., where the Muscle Shoals obstruction divides the river into two unequal portions, which are now navigated independently of each other.

As early as 1828 efforts were made to overcome this obstruction, and Congress donated 400,000 acres of land to the State of Alabama, for the purpose of building a canal around the shoals. The canal was built along the main obstruction, but was never properly completed, and it was eventually abandoned by the State authorities.

The importance attached to this river as a national highway, even by those who opposed internal improvements by the general government,

is evident from the fact that in 1824 Mr. Calhoun, then Secretary of War, reported this improvement as third in the order of importance of all those recommended to be undertaken by the government.

The following is an extract from his report:

> These three *great* works, the canal to the Ohio and Lake Erie, with the improvement of the Ohio and Mississippi, and the canal around the Muscle Shoals * * * are conceived to be the most important objects within the provision of the act of last session.

The act referred to provided—

> That the President is hereby authorized to cause the necessary surveys, plans, and estimates to be made of the routes of such roads and canals as he may deem of national importance in a commercial or military point of view, or for the transportation of the public mail. * * *

In 1867, an examination of the Tennessee River below Chattanooga was authorized, and an estimate was made for the improvement of the river, including the rebuilding of the canal around Muscle Shoals.

In 1872, an instrumental survey of the shoals was made under direction of Maj. Walter McFarland. Upon this survey, and a resurvey of Elk River Shoals in 1877, the present project for the improvement was based.

As the Muscle Shoals form the principal obstruction, and the river cannot be fully utilized for navigation until this principal barrier is removed, the operations for several years past have been directed chiefly to that object.

Considerable difficulty has been experienced in consequence of the great demand for labor in this region, which has made it necessary to increase the rates of pay in many cases, and has almost demoralized the masons and stone-cutters. The scarcity of common labor has been partially compensated for by increasing the use of steam machinery, horse-powers, &c.

During the last fiscal year good progress has been made, as will be seen from the following detailed report of operations.

1. ELK RIVER SHOALS DIVISION.

This part of the work consists in deepening the channel opposite Brown's Island and below by blasting rock from the reefs, and in building a retaining dam from the lower end of the island to the lower end of Milton's Bluff, from which point the channel takes the form of a canal 1½ miles long with two locks connecting with the navigable water between Elk River and Big Muscle Shoals. This canal and the locks will be of the dimensions described in the report on Bluewater division.

The following quantities of work were done on this division during the year:

Cubic yards channel excavation (rock)	9,445
Cubic yards earth excavation	6,168
Cubic yards ax-face stone cut	134
Cubic yards rock-face stone cut	70
Square feet stone cut by channeling machine	4,925
Cubic yards riprap quarried for dams	11,504
Cubic yards riprap put in dams	16,476
Cubic yards earth put in coffer-dam	3,716
Acres of timber cut from line of canal	18

It was hoped that last season's work would finish the necessary channel excavation, but funds were not available until July 9, 1880, and owing to the difficulty in getting a sufficient force together it was found impossible to get through before the work was stopped by high-water.

There is every indication that the present season will see this channel work completed, and the retaining dam so far extended that supplies can be shipped by water to the camp at Milton's Bluff.

The quarry at Trinity, from which it was proposed to get the dimension stone, has been stripped so far as to uncover all the stone needed, and a large quantity has been quarried and cut. A Wardwell steam channeling machine has been in operation there for several months, but owing to the great number and irregularity of the dry seams encountered it is found that the proportion of waste is excessive. A part of the dimension stone and most of the rubble can probably be quarried cheaper at one of the Milton's Bluff quarries, where stone for the riprap dams have been obtained; and if they cut to advantage it will save considerable expense for hauling.

Seventeen and a half acres of the land needed for the new canal below Milton's Bluff have been bought, and the title and jurisdiction secured in accordance with the provision in the appropriation act of March 3, 1879. Another small tract will be needed, and negotiations are pending with the owners which promise to secure that also.

This division is under the supervision of Assistant Engineer J. E. Willard, who is pushing the work vigorously.

2. BLUE WATER AND SHOAL CREEK DIVISIONS.

These divisions embrace the old canal around Big Muscle Shoals, 14½ miles long. This old canal was built nearly fifty years ago by the State of Alabama from the proceeds of the sale of 400,000 acres of land donated for that purpose by the general government, as already stated.

Owing to certain radical defects in construction of the canal itself, and to the neglect to complete it according to the plans of the Board of Public Works, so as to enable boats to pass the entire obstruction, the canal could only be entered at high stages of the river, and soon fell into disuse and decay. While some parts of the work were done in a thorough and substantial manner, other parts of vital importance were slighted or completed in a slip-shod way.

The present plans contemplate not only the rebuilding and enlargement of this old canal in the most thorough manner, but the extension of the improvement around Elk River Shoals, and the improvement of Little Muscle Shoals so that boats can get to the main canal at all stages of the river.

The canal trunk is to be from 70 to 120 feet wide at the water surface and 6 feet deep, and the locks are to pass boats 300 feet long, 60 feet wide, and drawing 5 feet of water.

The length of the canal is 14½ miles, and there are to be nine locks, and an aqueduct across Shoal Creek about 900 feet long and 60 feet wide. All the locks and the aqueduct masonry are founded on solid rock.

The following are the quantities of work done during the year on these divisions:

Cubic yards of solid rock excavated	10,610
Cubic yards of loose rock excavated	6,873
Cubic yards of earth excavated	35,583
Cubic yards of ax-face stone cut	1,932
Cubic yards of rock-face stone cut	1,011
Cubic yards of ax-face masonry laid	2,268
Cubic yards of rock-face masonry laid	1,442
Cubic yards of rubble masonry laid	4,758
Cubic yards of dimension stone quarried	7,004
Cubic yards of earth embankment	20,909

The present condition of the work is as follows:

Eight miles of the canal trunk are completed, 3½ miles partially completed, which, making allowance for the work yet to be done, may be estimated as four-fifths of the entire length completed.

The condition of the locks and other masonry is as follows:

No. 1, guard lock, 10 feet lift; foundation pit excavated, seven-eighths of the stone quarried and cut, and three-fifths of the masonry laid.

No. 2, 6-feet lift.
No. 3, 12 feet lift.
No. 4, 10-feet lift.
No. 5, 12-feet lift.
No. 7, 13-feet lift.

} The masonry of these five locks was *completed* and they are ready for the gates.

No. 8, 12-feet lift; foundation pit excavated and one-fourth of the masonry laid; one-half of the stone required for finishing this lock has been quarried and cut.

No. 9, 10-feet lift; one side of this lock is to be natural rock in position; the foundation pit has been blasted out and the foundation course on the river side nearly completed.

No. 10, 10-feet lift. This forms the outlet into the river and is founded 6 feet below extreme low-water. The site had been inclosed in a coffer-dam and all the earth and three-fourths of the rock had been excavated from the lock chamber. One-half of the stone needed to complete this lock had been quarried and cut.

The Shoal Creek aqueduct requires twenty-five piers and two abutments, the piers being 75 feet long, 11 feet high, and 3 feet thick. Four-fifths of the stone had been quarried and cut, and six of the piers and one abutment were completed. A large coffer-dam inclosing the foundations of twelve more of the piers was built and pumped out, and the bed-rock leveled off to receive the foundation.

Courses of masonry.

At *Blue Water Creek* seven piers and two abutments, each containing about 36 cubic yards of rock-face masonry, are required as buttresses to sustain a dam 288 feet long across the mouth of the creek, and to carry the bridge required at that point. Five of these piers and one abutment were built to an average height of 6½ feet.

The foregoing embraces *all the masonry required for the entire canal*, and ought to be completed in one year if funds are available for prosecuting the work continuously.

The canal trunk can be completed in the same time under the same conditions, and there would then remain nothing but the lock gates, wickets, and other details to render the canal navigable.

The next appropriation will be needed at an early day for continuing the work as thus indicated. It is often difficult, as at the present time, to procure the necessary skilled labor, and when once a sufficient force is organized it is very desirable, as a matter of economy, that they should be kept at work continuously.

In addition to the work of actual construction, a large amount of incidental work was done during the year in extending the railroad track for delivering stone at the locks, for which purpose some 2 miles of track was laid, and a substantial trestle one-fourth of a mile was built across Shoal Creek.

The steamer Hobson was employed several months in boating stone from the quarry below Florence to Lock 10, and from the quarries near Bainbridge to the riprap dams between that point and Florence. Two

small improvised steam tugs were also employed in towing stone across the river from the Lime Kiln Hollow Quarry.

The Blue Water and Shoal Creek Divisions have been under the immediate charge of Assistant Engineers Gielow and Hooke respectively, to both of whom the work is indebted for its highly satisfactory progress.

3. LITTLE MUSCLE SHOALS DIVISION.

This part of the work was continued during the year, and both channel excavation and wing-dams were so far completed as to render the Little Muscle Shoals navigable for all necessary purposes until the canal is completed.

4,432 cubic yards of rock were blasted from channel, 5,191 cubic yards of stone were built into dams, and 2,328 cubic yards of rock were quarried for dams.

The location of the dams and of the channel excavation are shown upon the accompanying map, Sheet III.

Before the work was begun a skiff could not safely pass the reefs near the head of these shoals at low-water, and it was feared that nothing short of locks and dams, or a continuous canal alongside the river as proposed by the Board of Public Works in 1830, would make this part of the river navigable, but sufficient has already been done to show conclusively that an open channel will answer the purpose, at least until the amount of commerce on the river has very much increased.

The completion of dam No. 1, and perhaps a few more spur-dams in the intervals between those shown on the map to check the velocity of the current, will make this obstruction navigable whenever the rest of the river can be navigated, and by the same class of vessels.

At the head of these shoals a channel has been blasted through solid rock 2,300 feet long, 110 feet wide, and to a depth of over 3 feet below the water-surface. A part of this excavation was made while the current was deflected into another channel by a temporary dam 1,300 feet long, and the balance was inclosed in coffer-dams, which were pumped out so that the men could work almost as on dry land.

Should it ever become desirable to undertake a more radical system of improvement for these shoals, which it probably will not until Colbert Shoals are improved by locks and dams, the present channel can be used and two locks and dams added, instead of building the very difficult and costly canal along the river, as proposed in the original plan.

This canal was estimated to cost $952,650, and it would have taken a much longer time to build it, whereas the present open channel has cost only $126,180, and is already navigable. There is no question as to the depth of channel being ample, and the only possible objection to the open channel is that the current is still quite strong in some places, but this can be still further improved by additional dams, as already suggested. And as the velocity is not so great at any point but that it can be overcome by any steamboat of respectable propelling power, the delay of up-stream boats, caused by retardation of the current, will not probably be more than it would be in passing locks, while all down-stream navigation will not only be free from the delay of lockage, but will be accelerated.

This division has been under charge of Assistant Engineer J. E. Willard, from the time work was commenced on it, and the satisfactory results are largely attributed to his energe and skill.

COLBERT SHOALS, DUCK RIVER SHOALS, AND OTHER OBSTRUCTIONS BELOW FLORENCE.

Owing to the almost imperative necessity for concentrating all the available force on the obstructions already referred to, it was not found

expedient to detach a sufficient force to undertake the improvement of the obstructions below Florence advantageously during the fiscal year, but I have procured from a number of pilots employed on that part of the river a complete list of all the obstructions they have met with between Florence and Paducah, a distance of 255 miles, and it is now thought that a snag-boat and party can be fitted out so as to get over this part of the river during the present low-water season and remove the snags and bowlders, which, together with the railroad bridge at Johnsonville, are the principal obstacles complained of.

This bridge, I believe, is owned by the Nashville, Chattanooga & Saint Louis Railroad Company, has a very narrow and badly located draw, and the company should be compelled to rebuild it or remove the gravel bar that has been formed by the piers, so that steamboats can pass it without the serious risk and frequent injury they now sustain.

The Memphis and Charleston Railroad bridge at Florence should also be provided with a draw. It was built when Florence was considered the virtual head of navigation, and has no draw whatever, while the height is not sufficient even at low-water to pass the class of steamboats that now run up to Florence even with their chimneys lowered.

This bridge which is on a mere branch road with but one or two daily trains, has already been a great inconvenience in boating stone to the Muscle Shoals Canal, and I believe it has no authority whatever for its existence even if it did not obstruct navigation.

I would respectfully recommend that Congress be asked for the necessary authority or instructions to the United States District Attorney, to take such action in the courts as will secure the removal of these two obstructions.

There are three steamboat lines running between Florence and Paducah, and other points on the Ohio, &c., and there is a line on the river above the shoals between Decatur and Chattanooga, connecting with Nashville, Chattanooga and Saint Louis Railroad, at Bridgeport.

The following letter from J. C. Cobb, for the Evansville and Tennessee River Packet Company, gives an idea of the present amount of commerce on this part of the river.

PADUCAH, KY., *August* 6, 1881.

Statistics of products shipped annually by boats from Florence, Ala., and points below on the Tennessee River, viz: 125,000 sacks or 750,000 bushels peanuts; 30,000 bales cotton; 100,000 bushels corn and wheat; 10,000,000 feet pine, walnut, oak, poplar and green lumber; 10,000 tons pig iron; 75,000 white-oak and pine staves; 1,000,000 barrel-staves; 500 tons leather; 6,000 cords tan-bark; 1,000,000 bushels stone coal; large quantities of hub, spoke, and axe handle timber; several thousand head of cattle, sheep, and hogs.

Shipments of merchandise by boats to above points amount to 50,000 tons annually.

John Gilbert, esq., President of the Evansville and Tennessee River Packet Company, kindly furnished me with the following information:

We are now running two boats weekly, the steamer Clyde, 500 tons burden, from Evansville to Waterloo, the steamer Silver Cloud, 600 tons burden, from Paducah to Waterloo; these two boats carry the mail twice a week from Paducah to Waterloo.

We run three boats in the Tennessee River, one between Cincinnati and Florence, the others as named above. We are now building a large boat to be used next season between Florence and Cincinnati. Besides our line of steamers there are two other boats that ran last season between Florence, Ala., and Cincinnati, Ohio, the Ariadne, 650 tons, and the Sidney, 700 tons burden. Also a tow-boat, 800 tons burden, and barges from Saint Louis, Mo., in the lower Tennessee River.

All these boats carried full cargoes of cotton and peanuts out of Tennessee River and brought back about half cargoes of merchandise during the business season. Our line of boats have at this time all the freight they can bring out of the Tennessee River at this stage of water.

Besides the gentlemen above named, I am indebted for information to Capt. J. B. Sleeth, of the steamer Silver Cloud, Louis D. Pell, and W. H. Smith, pilots; also, to Eugene List, clerk of the steamer Sidney.

I have tried to get information from the United States customs officials at various points, but all efforts have proved, thus far, futile.

MUSCLE SHOALS ROBBERY.

It becomes my duty at this point to record the circumstances of a robbery of public funds that occurred on the line of the canal between the Shoal Creek and Blue Water Camps, on the 11th of March last.

About 4 o'clock p. m. on that day, A. G. Smith, receiver of materials on the Blue Water division, while en route from Florence, where he had been to procure funds for paying employés, to the Blue Water Camps, 18 miles distant, was overtaken by three armed men, who covered him with their pistols while he was endeavoring to pass a gate, and compelled him to surrender his pistol, and the funds he was carrying, after which he was taken as a prisoner some 20 miles through by-paths and bushes into what is known as the "Barrens" (a sparsely settled country on the edge of Tennessee), where he was released, not, however, until after dark and while it was raining heavily, which insured great delay in his finding the way back to camp.

The amount of money taken from him was $5,240.18.

As soon as the robbery was known, every effort was made to intercept the robbers, and scouts were sent in every direction to scour the country north of the canal towards Nashville; but as the robbers were well mounted, and were, according to their own statements, old hands at the business, it was almost impossible to track them through the thinly settled country they selected for their line of retreat.

They were, however, followed up to where they crossed the Cumberland River, and one of them, William Ryan by name, was found in Nashville, where he was fully identified, and some $1,400, in gold and currency, was taken from his person. The District Attorney was notified, and requested to take necessary steps to secure the prisoner and attach the money, horse, and other property found in his possession, and he assured me that he had done so; but it seems that the prisoner had been allowed to dispose of his horse and some of the money before the proper legal restraints could be placed upon his actions. The district attorney now informs me that $1,280 is secure, and only awaits some legal process to be returned to the government.

The other two robbers were traced to Kentucky, and were reported to be in a certain known rendezvous and stronghold for some days, but I was unable to induce the marshal to capture them, although I went even beyond my authority in offering inducements. The local authorities refused to assist, and I was unable to procure authority to offer a reward or to get a detachment of soldiers to assist the marshal, and he abandoned the attempt to capture them.

There is no doubt of the identity of this gang with the celebrated James band of outlaws, the man Ryan having, in fact, been fully identified as one of them, at Kansas City, where he has been taken for trial, on a requisition from the Governor of Missouri, for certain robberies in that State.

The other two robbers, and, I fear, Ryan himself (for he was, at last advices, expecting to get released on bail), were doubtless engaged in the recent capture of the train near Winston, Mo., and as the governor has offered heavy rewards for them, they will probably be captured,

though there is little prospect that any more of the money stolen at Muscle Shoals will be recovered.

Full and conclusive affidavits have been collected, showing that the robbery was committed in the manner herein described, and they will be submitted at the proper time, with a petition to Congress asking that the accounting officers of the Treasury be authorized to pass to my official credit the amount stolen, less the amount recovered at Nashville.

The Tennessee River is in the collection district of New Orleans, and Paducah, Kentucky, and Chattanooga, Tennessee (recently established), are ports of delivery.

The original estimates of cost of improving Tennessee River below Chattanooga are	$4,133,000 00
Amount appropriated	2,095,500 00
Amount expended	1,823,650 00

Money statement.

July 1, 1880, amount available	$311,048 24	
Amount appropriated by act approved March 3, 1881	250,000 00	
		$561,048 24
July1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	258,173 85	
July 1, 1881, outstanding liabilities	31,025 00	
		289,198 85
July 1, 1881, amount available		271,849 39
Amount (estimated) required for completion of existing project		2,037,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		700,000 00

X 2.

IMPROVEMENT OF CUMBERLAND RIVER.

The improvement of this river was first undertaken by the State of Tennessee, in 1830, when an act was passed establishing a Board of Internal Improvement, and appropriating $60,000 for the rivers lying west of Cumberland Mountains, and East of Tennessee River.

The State of Kentucky also made appropriations at an early day for surveys and improvements of parts of the river within that State.

In 1830 Congress appropriated $30,000 for improving the Cumberland River, and in 1834 a survey was ordered upon which was based a project for the prosecution of the improvement under subsequent appropriations in 1836, 1837, and 1838. This survey was made by Capt. Howard Stansbury, and included the principal obstructions on the river.

In 1846 the State of Tennessee incorporated the "Cumberland Navigation Company for the purpose of improving the navigation of Cumberland River below the town of Nashville" with power

To enter upon said Cumberland River, and upon the lands upon either side below the town of Nashville, and within the State of Tennessee, and use timber, rock, stone, gravel, or earth in the construction of their work, &c.

* * * When said navigation, or any portion thereof, shall be completed, said coporation shall be entitled to receive such rates of toll per mile, at the discretion of the directors, as may be just and reasonable. * * * Whenever there shall be a depth of water on Harpeth Shoals of 10 feet, the locks hereby contemplated are to be opened free of charge, &c.

Whether anything, and, if so, what, was done under this franchise I have not ascertained.

In 1870 Congress authorized a survey of the Cumberland River from its mouth to the head of navigation, and upon this survey the project for the improvement was based. This project is essentially the one upon which operations have been prosecuted, although in 1875 a resurvey was made from Point Burnside to the mouth of Rock Castle River.

The nature of the obstructions on all parts of the river is, in general terms, the same, viz, shoal water, rapid current, snags, and overhanging trees at numerous points, and the method of improvement, as is plainly indicated by the following details of last year's operations, consists in blasting out and otherwise removing the ledges and loose rock, gravel, logs and snags, &c., and building wing and lateral dams to narrow the channel, and either cause the water to scour out a deeper channel, or produce additional depth by confining the water in a narrower space.

The method of improvement by locks and dams, which is the only one by which a low-water navigation can be secured above Nashville, or, in fact, below Nashville, excepting for small steamboats, has heretofore been considered too expensive to be undertaken, and the present plans are designed to give additional depth at medium stages of the river and to prolong the season of navigation. As stated in a former report, there are some nine steamboats of from 300 to 500 tons, and five from 125 to 260 tons, engaged in commerce on the river, running between Nashville and various points on the Cumberland, Ohio, and Mississippi rivers. During the high-water season the smaller of these boats also ascend the Caney Fork and Obey's rivers.

The Cumberland River is navigable for all of the above steamboats for six months in the year from Nashville to the mouthh of the river; from six to eight months from Nashville to the mouth for boats drawing 3 feet or less; and from nine to ten months from Nashville to the mouth for boats of about 20 inches draught. Distance, 192 miles.

Above Nashville the Cumberland is navigable to Point Burnside (crossing point of the Cincinnati Southern Railroad), a distance of 358 miles, for from four to six months for steamers of 3 feet draught or less, and from two to three months for larger boats.

From Nashville to Bucksville, 230 miles above, the Cumberland is navigable for from five to seven months for steamers of 3 feet draught or less, and from three to five months for larger boats.

From Nashville to Carthage, 120 miles above, the Cumberland is navigable from six to eight months for steamers of 30 inches draught or less, and from four to five months for the larger boats.

Flat-boating is not carried on extensively upon the Cumberland, except to bring out coal from points above Point Burnside, and this is only practicable during occasional high stages of river, about four or five during the year. A small quantity of produce and some tobacco find their way to a market by aid of the flat-boats.

The following are the details of work done during the past year on the different sections, as reported by Capt. L. C. Overman, United States Engineers, the officer in immediate charge of this improvement.

I.—BELOW NASHVILLE.

Work on this section was in progress at the beginning of the fiscal year, and was continued until December, when it was suspended on account of high water and cold weather. It was resumed on the 1st of June, and was in progress at the end of the year. Work was directed to the removal of obstructions at the following points, viz, Palmyra

Island, Dover, Upper and Middle Gatlin, Race Track, and Little River Shoals, and the work consisted in—

11,367 cubic yards of rock quarried, 23,206 cubic yards of rock built into dams, and the removal of 676 snags, roots, and overhanging trees.
Average daily force of men employed, 136.

The obstructions named are from five-eighths to nine-tenths completed.

This section from Nashville to the mouth of the river, a distance of 192 miles, in which the average fall is only 0.41 of a foot per mile, is worthy of a more radical system of improvement than that heretofore undertaken, and possibly the same remark may apply to a portion of the river above Nashville, and the Legislature of the State of Tennessee, during its last session, authorized the governor to appoint seven commissioners for the purpose of collecting information and urging Congress to make liberal appropriations for that purpose.

The present low-water has just developed the fact that, at the mouth of the river opposite Cumberland Island, the Ohio River is shoaling up so that boats drawing more than about 1 foot of water cannot enter the Cumberland River, and steamboat men are very naturally clamorous to have the channel re-established. As soon as an examination can be made of this obstruction, a special report will be made with a view to securing authority to apply the proper remedy.

The original estimate of cost of improving Cumberland River below Nashville was		$248,821 00
Total amount appropriated		220,000 00
Total amount expended		206,383 00

Money statement.

July 1, 1880, amount available	$23,961 11	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$38,961 11
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	24,455 24	
July 1, 1881, outstanding liabilities	888 87	
		25,344 11
July 1, 1881, amount available		13,617 00
Amount (estimated) required for completion of existing project		28,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		28,821 00

ABOVE NASHVILLE.

II. NASHVILLE TO KENTUCKY LINE.

[229 miles—average fall, 0.59 of a foot per mile.]

Work on this section was in progress at the beginning of the fiscal year, and was continued throughout the year, excepting during three months of the high-water season, when but little was done except in the way of preparation. Cub Creek Shoal, Holliman's Island, Sand Shoals, and Barlett's Bar were the obstructions worked upon, and the following are the items of work:

Cubic yards of gravel excavated	7,491
Cubic yards of rock excavated	2,778
Cubic yards of rock quarried	1,847
Cubic yards of rock placed in dams and riprap on bank	4,854

These shoals are from seven-eighths to nine-tenths finished, as contemplated in the existing project.

In addition to the work done at these points, a snag-boat removed from various points on this section 549 overhanging trees and 256 cubic yards of loose rock, and built 193 cubic yards of dam.

Money statement.

July 1, 1880, amount available	$18,673 92	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$33,673 92
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	13,661 58	
July 1, 1881, outstanding liabilities	818 17	
		14,479 75
July 1, 1881, amount available		19,194 17
Amount (estimated) required for completion of existing project		39,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		39,155 00

III. KENTUCKY LINE TO SMITH'S SHOALS.

[129 miles—fall, 0.73 foot per mile, or 94 feet in all.]

Work on this section was resumed in July, 1880, and continued five and a half months. Harmon's Creek Shoals, Wolf Creek Shoals, and Wild Goose Shoals were the obstructions worked upon, and the following quantities of work were completed:

Cubic yards of gravel excavated from channel	4,698
Cubic yards of rock excavated from channel	1,441
Cubic yards of rock quarried for dams	1,094
Cubic yards of rock placed in dams and riprap on bank	3,970

The first of these shoals is one-tenth completed, and the others five-eighths and three-fourths, respectively.

At other points on this section 130 snags and 16 overhanging trees were removed by a snag-boat.

Money statement.

July 1, 1880, amount available	$14,228 99	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$29,228 99
July 1, 1881, amount expended during fiscal, exclusive of outstanding liabilities July 1, 1880	9,968 16	
July 1, 1881, outstanding liabilities	631 26	
		10,599 42
July 1, 1881, amount available		18,629 57
Amount (estimated) required for completion of existing project		42,609 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		42,609 00

IV. SMITH'S SHOALS.

This formidable obstruction consists of four separate shoals, which, beginning at the upper end, are named, Shadowen Shoal, White Cliff Ripple, Long Shoal, and Mill Shoal, having an aggregate fall of 55 feet in 8 miles, most of this fall being concentrated in the lower end of Long Shoal and Mill Shoal.

As the velocity of the current at high-water is such that no ordinary steamboat could stem it, and as the volume of water at low stages is not sufficient to fill a channel of any useful dimensions, up-stream navigation and low-water navigation down stream are entirely impracticable, excepting at a much greater cost than has thus far been contemplated, either a system of locks and dams or wire-rope towage being necessary for such navigation.

When the improvement of this part of the river was begun in 1877 it was found that at Long Shoal the remains of a number of old dams could be

utilized by locating the navigable channel on the south or convex side of the river, and the dams on the north side; and so much weight was given to this consideration and to the supposed knowledge of the old pilots who are said to have located them that this plan was adopted. It was found, however, that the north or concave side was best for the channel, and, as intimated in the last report, it was decided to make the change.

The principal work needed at these shoals has consisted in smoothing the river bed, by breaking off the high points and ridges and filling in the low places, and building dams to narrow the channel and check the velocity of the current somewhat at the most rapid points; the general effect sought being a smooth and uniform channel of such depth and width that the frail coal-boats, or floating coal-bins, as they might properly be called, could descend in safety at what are called boating tides or rises of 4 or 5 feet

The dams consisted of a spur or transverse part from 200 to 400 feet long, and a longitudinal part extending from 500 to 700 feet down stream to retain the water collected by the spur.

Most of the work during the past season has been directed to removing these spur portions of the dams from the north to the south side of the stream, and in picking up and building into the dams such scattering stones, &c., as have collected in the river bed between the old dams.

It is hoped that the change will be entirely completed during the present season, and as the work most needed at the three other shoals has already been completed, it is not necessary that any further appropriation be made for this section at present.

The following quantities of work have been done during the working season, which embraced about eight months of active operations, with an average daily force of 114 men, under Assistant Engineer W. C. Crozer:

Cubic yards of solid rock excavated from channel	1,815
Cubic yards, loose rock excavated from channel	2,895
Cubic yards concrete in channel (to lengthen slope)	150
Cubic yards masonry paving in channel (to lengthen slope)	1,888
Cubic yards stone quarried	4,676
Cubic yards stone placed in dams	12,217

Navigation on this part of the river consists of coal-boats and sawlogs, of which a very large number are annually floated down and caught by a boom at Point Burnside.

Under provisions of the last river and harbor act, I have been directed to make a survey of Smith's Shoals with a view to ascertaining the practicability and cost of improving them by locks and dams, and this will be reported on in time to be laid before Congress, while this report is being acted on.

The estimate of cost of improving Cumberland River, above Nashville to head of Smith's Shoals, was $283,764. The whole amount appropriated for and expended on the sections specified is as follows:

	Appropriated.	Expended.
Nashville to Kentucky line	$83,000 00	$63,805 83
Kentucky line to Smith's Shoals	49,000 00	30,370 43
Smith's Shoals	100,000 00	92,929 06
Smith's Shoals to Falls of the Cumberland	4,000 00	4,000 00
Total	236,000 00	191,105 32

This river is in the collection district of New Orleans. Nearest port of entry, Nashville, Tenn.

Money statement.

July 1, 1880, amount available	$20 315 65	
Amount appropriated by act approved March 3, 1881	10,000 00	
		$30,315 65
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	20,823 22	
July 1, 1881, outstanding liabilities	2,421 49	
		23,244 71
July 1, 1881, amount available		7,070 94

V. CUMBERLAND RIVER, KENTUCKY, ABOVE THE MOUTH OF JELLICO.

In 1837 a survey was made by the State of Kentucky from the Cumberland Falls, in Whitley County, to the Kentucky State Line, 173 miles.

An appropriation of $10,000 was made by Congress, act of 1881, for the improvement of this part of the river, based on an examination made in 1880 by Lieut. W. L. Marshall, Corps of Engineers; and in order to prosecute the improvement economically it was decided to transfer to it the working party from the Smith's Shoals work as soon as completed, which will be about the 1st of September. Nothing was therefore done before the end of the fiscal year; but it is hoped that by utilizing the organized force from Smith's Shoals considerable work can be done before the end of the low-water season.

At present the project for improvement is confined to that part of the stream extending from (Pineville) Cumberland Ford to the mouth of Jellico Creek, a distance of about 110 miles.

In addition to short, rapid, rocky shoals—

It was found that the principal obstructions consist of nine mill-dams, which are not provided with chutes or aprons, and which therefore cause rafts to break up unless the river is at a very high stage. As I infer that no modification of these dams can be made without consent of the owners, I would respectfully recommend that the appropriation be applied to the removal of obstructions at Bolting Shoals and other points where navigation is most obstructed, and the removal of snags, overhanging trees, &c., between Cumberland Ford and the mouth of the Jellico.

If, upon investigation, it is found that any of the mill-dams can be modified at reasonable cost, and that the owners will consent thereto, the matter will be made the subject of special report to the department for further instructions.

The funds available, to be applied as above projected, and the appropriation ($15,000) asked for 1882–'83, to be applied in continuance of the same work.

Money statement.

Amount appropriated by act approved March 3, 1881	$10 000 00
July 1, 1881, amount available	10,000 00
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883	15,000 00

REPORT UPON THE RESOURCES OF THE COUNTRY BORDERING ON CUMBERLAND RIVER, ABOVE THE FALLS, IN THE STATE OF KENTUCKY, BEING SUPPLEMENTARY TO THE REPORT ON THE SURVEY OF THE FALLS OF THE CUMBERLAND (PROVIDED FOR IN RIVER AND HARBOR ACT OF JUNE 18, 1878) WHICH WAS TRANSMITTED TO CONGRESS MARCH 1, 1879, AND PRINTED IN HOUSE OF REPRESENTATIVES EXECUTIVE DOCUMENT NO. 106, FORTY-FIFTH CONGRESS, THIRD SESSION.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., January 14, 1881.

GENERAL: I have the honor to forward herewith a report by Lieut. W. L. Marshall, United States Engineers, of a reconnaisance made by him of the country bordering on the Cumberland River, above the falls, in the State of Kentucky.

This report is supplementary to one made last season by Assistant Engineer S. Whinery on the improvement of the Cumberland Falls (pages 1280–1282, part 2, Report of Chief of Engineers, 1879), and was on my recommendation authorized by the Chief of Engineers, by letter of September 13, 1880, in view of the fact that Mr. Whinery's report had been complained of as unjust to the section of country interested in the proposed improvement.

Lieutenant Marshall's instructions required him to give his principal attention to the material resources of the country above the falls, and incidentally to make such observations as will be of service in case any improvement of the river above the falls is undertaken hereafter.

The report is quite full, and, as far as I am able to judge, the conclusions are correct; and I would respectfully recommend that it be forwarded and made supplementary to Mr. Whinery's report.

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF LIEUT. W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Rome, Ga., November 17, 1880.

MAJOR: I have the honor to submit the following report upon the resources of the drainage area of the Cumberland River, above the Great Falls, in Whitley County, Kentucky. This report is intended as an appendix, or continuation of the report of Assistant Engineer S. Whinery, upon the proposed improvement of the falls, accompanying your annual report for 1879.

In this report I have made use of all accessible information, notably of the publications of the Kentucky State Geological Survey, and of the reports of engineers engaged in making surveys and estimates for the system of slackwater navigation inaugurated by the State of Kentucky in 1835 and 1837. I have quoted freely from these sources, in some cases without reference.

The information collected by myself was secured on an examination made by your order, between the dates October 24 and November 11, 1880, when I visited this area and traversed the counties of Bell, Knox, Whitley, and parts of Harlan, which counties embrace the entire drainage area of the Upper Cumberland River.

The area in question is about 2,500 square miles in extent.

Population in 1870	24,718
Taxable property in 1870	$2,153,290
Annual products, agricultural and manufactures	972,204

	Per acre.
Average value of land in Harlan County	$0 70
Average value of land in Bell County	1 63
Average value of land in Knox County	3 45
Average value of land in Whitley County	2 49

This area is but thinly settled by a poor mountain population, and its natural resources very little developed or known. I saw, however, sufficient to satisfy myself of its great value as a coal, iron, and timber producing region, and of its capacity to sustain a large population.

TOPOGRAPHICAL FEATURES.

The Upper Cumberland drainage is entirely mountainous. About its headwaters it drains the area included between the Pine and Cumberland mountains, and the slopes of the Black Mountains in Harlan County; cutting through Pine Mountain in a deep-cut gorge, at Pineville, near Cumberland Ford, in Bell County, it flows through a valley of greater or less extent, the bottom lands ranging in width from a few hundred yards to a mile or more, receiving many tributaries, through Knox and Whitley counties; the mountains gradually lowering in height and steepness from 1,500 to 2,000 feet above the drainage in Harlan County to from 400 to 1,200 feet in Knox and Whitley counties. At the mouth of Jellico Creek, in Whitley County, it enters a cañon or gorge, cut in the carboniferous conglomerate sandstone of the Cumberland plateau, and continues its course in this cañon beyond the limits of this examination. Above Pineville the mountain forms fill up the entire area included between the approximately parallel chains of the Cumberland and Pine mountains. There is but little bottom land along the streams, but upon the summits and flanks of the mountains are numerous little park-like valleys, coves, and swales well watered, and sweeping, rolling areas, adapted for cultivation. Lower down, in Knox and Whitley counties, the mountains recede from the river, in places steep and abrupt, in others presenting rolling uplands or plateaus of considerable extent, heavily timbered, and susceptible of cultivation.

The creeks and branches of the Cumberland are all fed by living springs, and upon them are found coves, bottoms, and plats of small extent, but quite fertile. Of the entire drainage area of the Upper Cumberland, I should judge, after riding over it, that not exceeding 35 per cent. is sufficiently level for cultivation, and that from 70 to 90 per cent. is covered by the unbroken primeval forest growth.

RESOURCES.

Soil.—Near the headwaters of the Cumberland, in Harlan County, in the Black Mountains, the soil is unusually strong for a carboniferous formation. Deciduous leaves, shrubs, and wood, decomposing for ages, mingled with the silicates of the rocks, rich in the alkalies, and with the calcareous material of the black shales, have produced a black, rich soil, in places several feet in depth, on the mountain summits and slopes, from which, by the action of the elements, the bottom lands and coves have been enriched.

Lower down, in Bell, Knox, and Whitley counties, the soil, though more gravelly and sandy and not so strong, is still capable of producing fair crops of the cereals and vegetables, even upon the summits of the ridges and plateaus. Owing, however, to the lack of transportation, the mountaineers raise no grain for shipment beyond the limits of their counties, but the production is confined to their own needs; the entire agricultural productions of these counties, for sale, consisting in live stock and wool.

For producing sheep this region is well adapted, the mountain grasses and shrubs affording extensive pasturage and browsing areas.

The strength of the soil may be best seen by the growth and character of the timber, walnut, hickory, white and blue ash, chestnut, poplar, birch, linden, gum; the first four mentioned of which are produced only by good soils.

John R. Proctor, State geologist of Kentucky, in his work on the "Resources of the North Cumberland Valley," says: The soils of this "entire region surpass any coal-measure soils within my knowledge"; compared, however, with the soils of the limestone belt of Kentucky and Tennessee they would be considered quite poor. In wheat they produce from 6 to 12 bushels per acre; in corn, from 15 to 50 bushels. The bottoms produce good grass, hay, and sorghum, also fair tobacco; but it is not as an agricultural region that this area will be populated and owe its future importance and development, even though the soil is capable of sustaining any population it may ever have.

Timber.—As already stated, the area covered by the primeval forests comprises from 70 to 90 per cent. (estimated) of the drainage area of the Upper Cumberland above the falls.

To these falls, and the lack of railroad and water transportation, may be due the nearly primitive appearance of this region. Thousands of square miles exist in Eastern Kentucky, broken only at intervals by narrow bottoms destitute of trees, and by small cultivated patches, heavily timbered by immense white oak, hickory of several varieties, black and white walnut, the former often reaching 5 feet in diameter of trunk, yellow poplar of immense size and length of stem, curly maple, and a species of gum, of light color and curly grain, which is said to be scarcely inferior to the maple as an ornamental wood, birch, linden, white and blue ash, long leaved and spruce pine; the pines, however, are not abundant nor of great size. The greatest growth of walnut and poplar, ash, and hickory is found in Harlan County, on the rich flanks and coves of the Black Mountains, although there is considerable walnut and poplar in Bell County and in the little coves and rich spots lower down the river, in Knox and Whitley counties. During the past 4 years great inroads have been made in Bell, Knox, and Whitley counties on the walnut and poplar, and in a very few years all the large walnut trees within reach of the river and its tributaries will have been removed. The trade in logs so far has been confined nearly exclusively to walnut; other timber than walnut and poplar has not as yet been cut or rafted to any extent. At present several companies are engaged in securing walnut logs, which are floated down to saw-mills, of which one is at the mouth of Jellico Creek, in Whitley County, and others, below the falls, at Point Burnside in Pulaski County.

From what I could see and learn I estimated that within 5 years all the walnut timber within reach of the Cumberland River will have disappeared. The demand is constantly increasing and the forests becoming very much reduced, but the quantity of white oak, poplar, hickory, ash, and other woods is immense and in demand. Of these the white oak is greatly the most abundant, but as it will not always float it cannot so readily be marketed.

Coal.—The thickness of the coal measures in this area approximates 2,000 feet above drainage. In this thickness, according to the Kentucky Geological Corps, there are about 20 distinct beds of coal, of which at least 6 are of good quality and workable thickness. I visited many openings in the counties of Bell, Knox, and Harlan, within easy reach of the Cumberland River and the roads of the country, near to but above the bottoms and drainage, varying in thickness from 28 inches in Knox County to 5 feet 4 inches in Harlan County. Near Flat Lick, in Knox County, there are 6 deposits of workable thickness, 4 feet, 3 feet, 5 feet 3 inches, 4 feet 8 inches, 4 feet 5 inches, 31 inches, the last named being a good cannel coal, but it is in Harlan County that the greatest development of coal beds exists. A persistent bed 8 feet thick is reported, and one of 14 feet in thickness, but I visited no vein of greater thickness than 5 feet 4 inches in that county, but as the 8-foot bed and also a 6-foot bed is found just over the line in Southwest Virginia, in the same coal field, I have little doubt of the existence of these thick veins in Harlan County, Kentucky. In Knox and Bell counties many well-to-do-farmers have open coal banks near their houses, and I followed a 4-foot vein for 8 miles within loading distance of the proposed route of the Cincinnati, Cumberland Gap and Charleston Railroad. The thick veins are not found in the lower part of the area under consideration, those worked at Livingston, the present terminus of the Louisville and Nashville Railroad, Knoxville branch, varying from 29 inches to 39 inches in thickness. Similar veins, I understand, are worked near the mouth of Rock Castle River, above Smith's Shoals. John R. Proctor, State geologist of Kentucky, in his report of the "Resources of the North Cumberland Valley," says, "The coal measures have here a thickness above drainage * * * thicker than elsewhere in America. * * * Enough has been done to establish the existence of many beds of workable thickness and of very superior quality."

Professor Crandall, in volume IV Kentucky Geological Reports, second series, says:

"The thickness of the coal measures is greater by many hundred feet than in any other part of Kentucky. The number of coals is also greater. * * * The quality of the coals of this valley is most excellent. The proportion of ash and sulphur is very low in all that have been analyzed, with the exception of one cannel coal, and the fixed carbon is high."

In Virginia, near the head of Powell's River, the coals of the same field have been examined by Prof. J. J. Stevenson, who remarks of the 6-foot vein: "At one place where the bed had been dug into a little, it yields the best kind of bituminous coal, fat and coking, but friable, with no appearance of sulphur, and making no clinker. It is a good blacksmith coal, and no doubt will make a good coke; a piece of ill-made coke shows that the best coke can be got from it."

Also of the 8-foot vein: "This 8-foot seam will yield a coke with considerable less than *three per cent. of ash*, and with but little more than $\frac{5}{10}$ of 1 per cent. of sulphur. Such would be a marvelously rich coke, the percentage of fixed carbon being somewhat more than 96. The Connellsville coke has somewhat less than 90 per cent. of fixed carbon; the ash is between 9 and 10 per cent., while the average sulphur is about $\frac{8}{10}$ of 1 per cent."

Analyses of the Cumberland coals and the Pennsylvania coals, made by competent

chemists, compare very favorably for the Cumberland coals, and demonstrate their, superiority for manufacturing purposes. The thickness of the veins, their easy access. locally, their position above the drainage, and the cheapness with which they can be mined, will undoubtedly cause them to be sought when means of transportation are furnished. It exists in inexhaustable quantity, everywhere exposed, to be opened by simple adits. Coal is now delivered in Pineville at $1 per ton.

Iron.—I have learned of no beds of iron ore of *known thickness or extent* in this area. Many specimens of iron ore, mostly carbonates and brown hematites or limonites, were shown me, picked up from the beds of the creeks and by farmers in plowing their fields. There has been no search made for iron, but as this coal-field elsewhere furnishes many beds of iron ore, it doubtless exists in close proximity to the coal. I heard of iron ore and saw specimens from near Barboursville, in Knox County, from the flanks of Pine Mountain, in Bell County, from the Elk Fork, from Cumberland Falls, and from various points in the southern part of Whitley County, mostly limonites and carbonates. The extent of any bed is not known to me. But on the southeast flank of the Cumberland Mountains extend very persistent deposits of the red (fossil) hematite ore in almost inexhaustible quantity, within 8 miles of the coal deposits on Yellow Creek, near Cumberland Gap, and within easy access (further west) of the coal on Elk Creek and the Clear Fork of Cumberland River, in Whitley County; also in Pulaski County, Kentucky, below the falls, are many known deposits of limonite ore. Pine Mountain will almost certainly furnish near its base the red hematite (fossil) ore, which is persistent in that formation from Pennsylvania to Alabama; in fact, pieces of this ore have already been found near the base of this mountain, but not in place, as the foot is covered up in *debris* from the mountain itself and with vegetable matter.

From the above facts it may be seen that the natural resources of the Upper Cumberland Valley are great but undeveloped. As an agricultural region it will be of no value particularly. For its capabilities as a manufacturing region, as a possible source of production of iron, steel, coal, timber, and manufactures of wood, it cannot well be surpassed by any similar area in America.

So far the timber only has been utilized, and that but sparingly, the insufficiency of the Cumberland River as a means of transportation, due to its many mill-dams, shoals, and falls, and the necessity for breaking up the rafts to pass the falls, being a great hinderance to the further development of even this industry.

This area can never be of any great value without transportation facilities, and of these railroads alone can meet the demands of the country. The torrential nature of the Cumberland River will, even with a complete system of slackwater, forever prevent continuous safe navigation throughout the year over the part of the river between the mouth of Jellico Creek and the foot of Smith's Shoals, unless some system of slackwater or canalization may be devised, at practicable cost, secure against the rises and freshets of this stream.

THE CUMBERLAND RIVER.

Your instructions required me to examine incidentally the Cumberland River, in the neighborhood of and above the falls, and to report any facts bearing upon its improvement, &c., and my conclusions based thereon.

I have the honor to submit the following remarks, based upon a cursory examination of the stream from Harlan County line to Cumberland Falls, and upon information derived from raftsmen and the inhabitants of its valley.

The Cumberland, above the Great Falls, may for description be divided into three sections, each differing distinctly in navigable qualities and characteristics from the others:

I. From the headwaters of the river in Harlan County, Kentucky, to Cumberland Ford, in Bell County.

II. From Cumberland Ford to the mouth of Jellico Creek, in Whitley County, about 110 miles by water.

III. From the mouth of Jellico Creek to the Great Falls, in Whitley County, about 16 miles by water.

I. In the first, after collecting the water of its upper tributaries, the main stream possesses the characteristics of all mountain streams near their head—rapid, with great slope, comparatively short pools, rocky and steep shoals; it cannot be improved save at great expense for steamboat navigation, or even for barges down stream, except during times of very high freshets. All that can be done for this section is to remove the rocks above low-water mark, and cut through the worst rock reefs, to allow the safe rafting of logs. Poor Fork, Clover Fork, Yellow Creek, and in fact all the tributaries of the Cumberland, at high-water, have sufficient depth of water to bring down logs singly to the main stream, there to be rafted. At low-water the river is insignificant.

II. From Cumberland Ford at Pineville to the mouth of Jellico Creek, the river varies in width from 100 to 300 feet, with long pools of slackwater, and short, rapid shoals of rock and bowlders; from the height of the mill-dams, and the length of the

backwater occasioned by them, I estimate the average fall at about 1½ feet to the mile. A short distance below Cumberland Ford, at Barboursville, in the Horseshoe Bend above Williamsburg, at Bolting Shoals, and below the dam at Williamsburg, are quite formidable shoals of rock and gravel, over which, at low-water, in less than ¼ of a mile, are falls of from 18 inches to 3 feet (estimated).

Between Pineville and the mouth of Jellico Creek are 9 mill-dams averaging 6 feet in height each; two of them are 9 feet, two are 7, and the rest 6 feet or less in height, viz:

1. Ely's mill-dam, 5 miles by land below Pineville, 9 feet high.
2. Bay's mill, just above Rock House Ford, 4¼ miles above Barboursville by land.
3. Barboursville mill-dam, 9 feet high; this dam is at the head of quite a shoal, with a fall of at least 3 feet in 2,000 feet.
4. McNeill's mill-dam, 7 miles below Barboursville by land, 7 feet high.
5. Evan's mill-dam, about 4 miles by water below McNeill's, 4 feet high; said to back water to McNeill's dam.
6. London mill dam, 18 miles by land below Barboursville, and 10 miles by land above Williamsburg.
7. Sutton's mill-dam, 6 miles above Williamsburg by land.
8. Williamsburg dam, 6 feet high.
9. Jones's mill-dam, 6 miles by water below Williamsburg.

These dams are for the most part quite substantially built of cribs of round logs filled with stone; are not provided with chutes and aprons, and are the greatest obstructions to rafting lumber on the Upper Cumberland, since the stage of water must be so high as to allow rafts to pass over without breaking to pieces. I was informed that there are on an average about 7 freshets or tides in the course of a year when this can be safely done. If they were removed there would be at least 3 months in the year in all when rafting could be securely carried on. In this section the mill-dams must by their slackwater conceal many minor shoals and obstructions, but from appearances and from the comparatively slight fall in the river, I would estimate that with an expenditure of not exceeding $500 per mile navigation for light steamers (by warping over the steeper shoals) might be secured from Pineville to the mouth of Jellico Creek for about 4 months in the year, but this would require further examination to determine.

There is a rainfall in the Upper Cumberland Valley of about 60 inches per annum. This great rainfall coming principally in the winter and spring months over a mountainous area, drained by streams with steep slopes, causes in the Upper Cumberland sudden rises and freshets, which nearly as rapidly subside. At Pineville, where the slope of the river is greatest, the river rises 28 feet; at Barboursville, 32 feet. Rises of 30 feet have occurred in 24 hours. On the crest of Cumberland Falls the highest rise is about 6 feet; at the foot of Smith's Shoals, 73 feet. During a dry summer, when the springs dry up, the river nearly disappears. When I visited the Cumberland, November 1, the discharge of the river at Barboursville was not exceeding 90 cubic feet per second; at extreme low-water it scarcely furnishes water to run continuously a 20-inch turbine wheel under a head of 8 feet, full gate, at the mill there.

III. From the mouth of Jellico Creek to the Cumberland Falls the river flows through a very poor, rugged country in a deep gorge cut in the Cumberland Plateau, in a succession of rapids and shoals, with short pools of still water between them; it is not so much obstructed by rocks and bowlders as just below the falls, but the river is so rapid and dangerous therefrom that rafts, abandoned at the mouth of Jellico Creek, are broken up and pass the falls as single logs. No improvement of this part of the river which would allow up-stream navigation, or, indeed, absolutely safe down-stream navigation for coal barges, can be made, except at great expense.

In a distance of about 12 miles or less the following shoals occur, having falls over them (estimated) at from 2 to 6 feet over short distances. The draw, or diminution of head over the great falls at time of high-water, increases the fall very materially for some distance above them.

1, Rough Shoal; 2, Terrapin Shoal; 3, Bee Shoal; 4, Buck Shoal; 5, Long Shoal; 6, Slick Shoal; 7, The Pitch; 8, Thunderstruck Shoal; 9, Bunche's Island; 10, Devil's Race—all quite formidable obstacles.

The most that can be done in this section, unless a complete system of slackwater is devised and executed, is to remove the rock and drift from the channel, to form chutes over the shoals for logs and rafts. A close reconnaissance would be necessary to determine the cost.

As bearing upon the subject of the improvement of the Cumberland Falls, the following additional data concerning the falls and the river below are given:

Height of falls and rapid immediately above, by Assistant Engineer S. Whinery's survey	65.2 feet.
Same by a survey made by the State of Kentucky in 1837	70.0 feet.

Whinery's survey was made when the river was several feet above low-water, which

may account for the difference. Whinery's estimate for canalling the falls is $368,500, which is not a liberal one, even for the contracted canal proposed.

In 1837 a survey was made by the State of Kentucky, from the Cumberland Falls, in Whitley County, to the Kentucky State line, 173 miles.

From the falls to the mouth of Laurel River, 10 miles, the descent in the water-level was found to be 85 feet (or 8.5 feet to the mile); from the mouth of Laurel River to the head of the Great Shoals (Smith's), 24 miles, the descent was only 31 feet (1.3 foot to the mile); from the head of the Great Shoals to the foot, 9 miles, nearly 55 feet (average 6.0 feet to the mile, but on Long Shoal, 13 feet to the mile); and from the foot of the shoals to the State line, 129 miles, only 94½ feet, an average of only 8.8 inches to the mile.

The estimated cost of this improvement, consisting of 13 locks and dams, for steamboat navigation, from the mouth of Laurel River to the Tennessee line, 163 miles, was $1,578,871, but it might be accomplished for $510,548, so as to enable steamboats to run from 3 to 5 months in the year, and coal-boats to descend when there should be water enough for them to pass the minor ripples. From the mouth of Laurel to the Great Falls the improvement was considered impracticable, comparing expenses with expected results.

To utilize, then, the Cumberland River as a safe means of transportation, the following estimates have been made:

Canalling around the falls	$368,500
From Laurel River to Tennessee line	1,578,871
Pineville to mouth of Jellico (4 months)	55,000
Total	2,002,371

Leaving the removal of the obstructions for 10 miles below the falls, in which there is an average fall of 8.5 feet to the mile, and for from 12 to 16 miles above the falls, in which there is a great descent in the water-level, not estimated for at all.

When we consider the great slope of this section of 26 miles from the mouth of Jellico to the mouth of Laurel River, and the torrential nature of the Cumberland River, the difficulty of improving it by any ordinary methods of slackwater can be readily seen. For steamboat navigation or for safe flat-boat navigation not less than fourteen additional locks and dams would be required, at a probable cost of not less than $80,000 for each set, or an additional amount of say $1,120,000. It is evident that unless there could be an assured market below the falls for the inexhaustible supply of coal, iron ore, and timber in the four counties above, this would be an excessive price to pay for opening this water line, but the iron and coal having passed the falls comes in direct competition not only with the minerals from Laurel and Pulaski counties, Kentucky, but also with that from the coal and iron deposits of Pennsylvania, Virginia, and the western coal-field of Kentucky, which have no such obstacles to free and cheap navigation to encounter.

Timber at present is and will be for many years the only product for water transportation from the Upper Cumberland to points below the falls, and for its transportation the only work required will be that on the upper river already described, and the removal of the immense sandstone bowlders from the channel below. Logs already pass the falls very freely, but many are lost on the rocks and drift-piles below them.

For the rest, the Louisville and Nashville Railroad, Knoxville Branch, and the Kentucky Central Railroad, in conjunction, have decided upon completing the line from Livingston, the present terminus of the former road, to Careyville, Tennessee, via Williamsburg, where the road will cross the Cumberland. The officials of the Cincinnati Southern road also have announced their willingness, I understand, to build a short branch 12 miles in length from Pine-Knot Station to the mouth of Jellico, if the river should be improved above that point. Should either of these roads be built—and it is probable that both of them will soon be—the improvement of the river from Pineville to the railroad crossings, about 110 miles, would go far toward meeting the present needs of this section for transportation facilities, at very reasonable expense, and without encountering the dangerous navigation of the great shoals and falls below.

There are appended hereto tables of analyses of Cumberland coals and iron ores.*

I am, sir, very respectfully, your obedient servant,

W. L. MARSHALL,
First Lieutenant of Engineers.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

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* Omitted. Printed in House Ex. Doc. No. 57, Forty-sixth Congress, third session.

X 3.

IMPROVEMENT OF THE HIWASSEE RIVER, TENNESSEE.

The improvement of this stream received due consideration from the State of Tennessee, it forming a part of the East Tennessee district, provided for by act of January, 1830. At least, work has been done upon the stream by State authority, though with little permanent benefit to its navigation.

An examination was made by the United States in 1874; and, based upon it, the first appropriation, $10,000, was made by act of 1876.

The obstructions are gravel bars, rock reefs, bowlders, &c.

The plan of improvement is, to secure an additional depth at shoal places by excavation, and narrowing the water-way by wing-dams, securing a channel 2 feet deep and 40 feet wide, the regimen of the river assisting to render the work permanent.

Active operations were carried on by hired-labor system, under local charge of Assistant Engineer John S. Crary, during a period of about three months, with an average daily force of twenty-four men.

During the year about 157 cubic yards of solid rock, near Bate's Ford, were blasted, and 52 cubic yards of bowlders, a few snags, and a large quantity of drift, were taken from the channel between Charleston and Camp's Island Shoals; 280 cubic yards of rock quarried, and 500 cubic yards put in dams; also some bowlders and reef-points were removed between Charleston and Chatata Creek, and at Chatata Shoals.

The present condition of this stream is, a good navigable channel for the Tennessee River steamboats from its mouth to Charleston, except during extreme low-water; and above Charleston the channel has been improved at Brindley's Shoals and other points.

A working party is now actively employed at the shoal near the mouth of the Ocoee.

The funds on hand, and the appropriation asked for 1883, $2,500, can be profitably expended, principally in extending the improvement above Charleston, as originally projected.

The commerce of this river is carried on by steamboats from the Tennessee River, and, to a limited extent, by keel boats, especially on that portion above Charleston.

The freight is chiefly grain and other farm products, and during the past year has been very heavy, one firm having kept a steamboat busy for some months in their trade.

Most of the traffic, however, is carried on in such an irregular way that it is impracticable to get reliable statistics in regard to it.

This stream is in the collection district of New Orleans, being tributary to the Tennessee River. The nearest port of delivery is Chattanooga, Tenn.

The original estimate of cost was	$20,000 00
Which was increased in 1879	10,000 00
Making total estimate of cost of improving Hiwassee River	30,000 00
Amount appropriated	27,500 00
Amount expended	25,741 74

Money statement.

July 1, 1880, amount available	$3,000 00	
Amount appropriated by act approved March 3, 1880	1,500 00	
		$4,500 00

July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	$2,405 48	
July 1, 1881, outstanding liabilities	336 26	
		$2,741 74
July 1, 1881, amount available		1,758 26
Amount (estimated) required for completion of existing project		2,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		2,500 00

X 4.

IMPROVEMENT OF FRENCH BROAD RIVER, TENNESSEE.

The French Broad River enters Tennessee at Paint Rock and joins the Holston River 4½ miles above Knoxville. The distance from the North Carolina and Tennessee State line to the mouth of river is about 121 miles.

It is evident that this stream received a part of the appropriations made by the State of Tennessee for improving her rivers in the East Tennessee district, for we find that her general assembly, in February, 1836, appointed commissioners to superintend the improvement at Hanging Rock and Seven-Island Shoals, about 30 miles below Dandridge, which was stated to be, when surveyed in 1870, "the greatest obstruction on the French Broad River."

A limited survey was made, as stated, in 1870, from Leadvale to the mouth of the river. An examination was made in 1875 from Henderson County, North Carolina, to Leadvale.

Congress, in 1880, appropriated $10,000 to begin work, based upon these examinations.

Most of the State dams have been ruined by fish traps, and the navigation injured by mills taking the water supply. A few of the dams can be repaired and made available, and others removed, as may be found most advantageous, in the progress of the present plan of operations, which plan is to excavate solid rock, gravel, bowlders, and snags from channel, to cut down overhanging trees, to build and repair the necessary rubble wing-dams, so as to permit the passage of vessels drawing 2½ feet of water, as high as Leadvale, during the low-water season; a slackwater navigation being the only feasible one above Leadvale.

Active operations were carried on by hired labor under the local charge of Assistant Engineer W. A. Thoms and since June 15 under Assistant Engineer John S. Crary, for about four months, with an average daily force of twenty-five men.

During the year the necessary derrick and quarter-boats and flatboats were built, and work was done at the following points: A reach of about 21 miles of river between Dandridge and Leadvale, viz, Ten Island Shoals, Allen's Mill Shoals, Taylor Shoals, Copeland's Shoals, Gaines' Mills Shoals, Swan's Island Shoals, and also at Fain's Island Shoals, one mile below Dandridge.

About 520 cubic yards gravel were taken from the channel, 957 cubic yards of rock quarried, and 787 cubic yards put in dams, 300 cubic yards of earth embankment and 575 linear feet of new crib-dams built and 1,250 linear feet of old (State) dams repaired.

Work is progressing at Fain's Island Shoals and Evans' Island Shoals, 1 and 10 miles, respectively, below Dandridge, and recently several boats, grain-laden, have passed down to Knoxville, the owners reporting that

the risk would not have been run if they had not been notified that they could safely pass these islands.

The available funds and appropriation ($15,000) asked for year 1883 can be profitably applied in continuing the work and rendering permanent the improvements already begun, by clearing up the channel and narrowing the water-way from Leadvale to Knoxville. Above Leadvale, to remove troublesome bowlders, snags, drift, &c., from the channel, so far as the interests of navigation may demand.

The commerce of this river, present and prospective, is largely in grain, which is carried to Knoxville in flat-boats.

The heaviest grain dealers in that city report that of the grain received at Knoxville by river during the year, amounting to about 200,000 bushels, about 65,000 bushels were brought down the French Broad River.

This stream is in the collection district of New Orleans. The nearest port of delivery is Chattanooga, Tenn.

From the Tennessee and North Carolina State line to Leadvale, no estimate of cost of improvement was made, for reasons given by Major McFarland in 1876, neither was an estimate submitted for the 20 miles of river between Leadvale and Dandridge.

The original estimate of cost of improving the French Broad River from Dandridge to its mouth is	$150,000 00
Amount appropriated	13,500 00
Amount expended	4,660 12

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	3,500 00	
		$13,500 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	3,820 12	
July 1, 1881, outstanding liabilities	840 00	
		4,660 12
July 1, 1881, amount available		8,839 88
Amount (estimated) required for completion of existing project		136,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		15,000 00

X 5.

IMPROVEMENT OF CLINCH RIVER, TENNESSEE.

The Clinch River enters Tennessee about 35 miles below Osborn's Ford, Scott County, Virginia, which is practically the head of high-water navigation, and after a course in Tennessee of 230 miles, enters the Tennessee River at Kingston, Tenn.

The area drained by the Upper Clinch is about 1,436 square miles.

As early as January, 1830, the State of Tennessee appropriated $150,000 for the improvement of her navigable rivers, allotting $60,000 to that part of the State lying east of the Cumberland Mountains, known as East Tennessee, and the same amount west of the Cumberland Mountains, and east of the Tennessee River.

Again, in 1842 the State appropriated $100,000 for the rivers in the East Tennessee district, and in January, 1844, appointed six commissioners to direct the work, by dividing the river into sections, and letting the work to the lowest bidders, in the several counties where the work was to be done, which consisted principally of removing logs, bowlders, and building wing-dams.

Several gravel bars were plowed up, to be carried away by high-water, but little permanent benefit resulted.

Several of these dams are obstructions, and will be removed, and others will be repaired, and modified as may be necessary.

An examination of this stream was made in 1875, and an examination of the upper river, above Haynes, Union County, Tennessee, was made in 1881. The obstructions were found to be large bowlders, shoals of gravel, and loose rock, ledges extending across the channel, having elevated rocky points above low-water, mill-dams, fish-traps, snags, and overhanging trees.

There are about thirty obstructions between Haynes and the State line that need improvement.

The plan adopted is to remove the most dangerous obstructions down to extreme low-water mark, and where necessary to build wing-dams, and to secure a permanent increase of depth of water in channel, which it is hoped to attain by blasting rock in channel, &c., securing for about 145 miles of the lower river, at ordinary low-water (from its mouth to Clinton), about 2 feet, and from Clinton to Walker's Ferry (Haynes) about 1½ feet.

The river is now used only for rafts and flat-boat navigation at flood stages.

Active operations were begun August 30, 1880, under Assistant Engineer E. C. Tollinger, and closed December 16, 1880, and recommenced in June, 1881, under Assistant Engineer W. G. Sanborn.

There was employed during the season an average daily working force of seventeen men.

The work was done principally at Haynes, Center's Ford, Ladd's Shoals, Bletcher's Shoals, Brushby Bend Shoals, McKinney's Shoals, Mettle Rock, Straight Shoals, and Sycamore Shoals. This latter forms one of the worst obstructions on the upper river.

After procuring the necessary derrick, quarter and flat boats, and fitting them for service, there were removed from the channel—

10 cubic yards of solid rock;
214 cubic yards of loose rock;
325 cubic yards of rock ledges;
24 cubic yards of old dams;
136 snags;
112 overhanging trees;
And 140 cubic yards of rock were put in wing-dams.

The condition of the river is much improved, and appears to give satisfaction to the raftsmen and boatmen, who acknowledge the present and future benefits to navigation.

The funds available will be used mainly for removing from the channel snags and other obstructions to high-water navigation, blasting ledges, and building and repairing wing dams, working above and below Haynes.

Working parties are now doing good service at Freel's Island, about 48 miles above Kingston, and at Hunter's Shoals, above Haynes, where the river is about 600 feet wide, obstructed by loose rock and ledges.

The appropriation of $10,000 asked for the year 1882–'83 can all be profitably expended in improving the high-water navigation, enabling rivermen to bring out the cargoes of staple products, on the frequent "rain tides," with less difficulty and danger; and this sum would make it practicable to employ more working parties, and thereby secure more marked results, at a less average cost, than is usual with small appropriations.

A very large proportion of the lumber and grain brought to Chattanooga comes down the Clinch River, and a part of the trade of this stream is diverted at Clinton, where it is crossed by a branch railroad leading to Knoxville.

This river is in the collection district of New Orleans. The nearest port of delivery is Chattanooga, Tenn., recently established.

The original estimate for improving Clinch River, in Tennessee, was		$26,400 00
Amount appropriated		13,000 00
Amount expended above Haynes	$896 63	
Amount expended below Haynes	2,856 37	
		3,753 00

Money statement.

July 1, 1880, amount available	$10,000 00	
Amount appropriated by act approved March 3, 1881	3,000 00	
		$13,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	3,404 39	
July 1, 1881, outstanding liabilities	348 61	
		3,753 00
July 1, 1881, amount available		9,247 00
Amount (estimated) required for completion of existing project		13,400 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,000 00

EXAMINATION OF CLINCH RIVER, VIRGINIA AND TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., January 27, 1881.

GENERAL: I have the honor to submit the following report on the examination of Clinch River, in the counties of Hancock, Hawkins, and Claiborne, Tennessee, and Scott and Russell, Virginia:

The examination was begun at Nash's Ford and ended at Haynes, near the Union County line, a distance of about 161 miles.

This river was examined in 1876 (see Report of Chief of Engineers, 1876, Appendix P), and an appropriation of $10,000 was made in 1880 for beginning the improvement recommended.

The present examination was made by Mr. E. C. Tollinger, who has been employed on that improvement during the past season, and who is, therefore, especially qualified to judge as to the additional work required and the cost of executing it.

From his report, hereto appended, it will be seen that the obstructions consist of rock reefs, bowlders, gravel bars, mill and fish dams, snags, and overhanging trees, the removal of which, and the building of a few wing-dams, will afford the necessary relief to the rafting and boating interests navigating this river.

Some of the most serious obstructions to navigation in this river—the mill and fish dams—are deliberately placed there by private parties, and most of the snags are carelessly thrown into the river in clearing trees from the banks. It would seem that some law to prevent this wanton obstruction of navigable streams would have a salutary influence.

The estimated cost of the proposed improvements is $24,510, a sum considerably greater than the estimate of 1876, but for the reasons already stated, the present estimate will probably be found nearer correct.

The area drained by the Upper Clinch is about 1,436 square miles,

with a population of about 46,134, and a true valuation (census of 1870) of $7,087,820.

The proposed improvements would be of a very permanent character as the regimen of the river is very stable; and it is probable that a small annual expenditure for timely repairs would maintain a good navigable channel for many years to come.

This river is in the collection district of New Orleans, and the nearest port of delivery is Knoxville.

A detailed statement in tabular form of the various obstructions, with distances, quantities, &c., will be found herewith.

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. E. C. TOLLINGER, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *January* 25, 1881.

MAJOR: I have the honor to submit the following report on the examination of Clinch River, from Nash's Ford, Russell County, Virginia, to Haynes, Union County, Tennessee, made in accordance with your instructions of December 23, 1880.

The Clinch is one of the largest tributaries of the Upper Tennessee. Its principal source is the Clinch Mountains, Russell County, Virginia. Its tributaries are Indian Creek, Guest's River, Strong Creek, North Fork, Sycamore Creek, Powell's River, and Emory River, on the north, and the Maiden Spring Fork, Big Cedar Creek, Copper Creek, Big War Creek, and Bull Run on the south. Many smaller streams flow in from either side. It drains (or in part) in Virginia that territory embracing the counties of Tazewell, Russell, Wise, Scott, and Lee, and, in Tennessee, of Hancock, Hawkins, Granger, Claiborne, Union, Anderson, and Roane Counties. For convenience of description and reference, the river may be divided into three sections.

Section 1 includes that part from Nash's Ford, Russell County, Virginia, to Wheeler's Ford, Wise County, Virginia, a distance of about 30 miles.

Section 2 includes that part from Wheeler's Ford to Osborn's Ford, Scott County, Virginia, a distance of about 21 miles.

Section 3 includes that part from Osborn's Ford to Haynes, Union County, Tennessee, a distance of about 110 miles.

Nash's Ford is 6 miles north of Lebanon, the county-seat of Russell County, Virginia.

The general course of the river is southwest. From Nash's to Wheeler's there are no serious obstructions to flat-boat navigation. The channel is well fixed, with nearly a uniform width, except at the shoals. The pools are generally long, shoals and islands few, curves gentle, fall moderate. The hills and ridges are well wooded, black walnut, poplar, cedar, beech, oak, and pine abounding; very little farm land adjoining the river, the valley land laying back from $1\frac{1}{2}$ to $2\frac{1}{2}$ miles.

At Wheeler's Ford a great change takes place, and, for a distance of 14 miles, the river has many characteristics of a mountain stream. The curves are sharp, the pools short, the fall great, channel frequently contracted, and the sharp, craggy projections from the sides extending well out into the river, together with the boldness of the bed, precludes forever any attempt to improve this part of the river, except to lessen the danger.

From Osborn's Ford to Haynes there are no serious obstructions. The pools are long and deep, curves gentle, fall moderate, till we come to the Thirty-mile Shoals; then, for a distance of about 20 miles, we have a succession of short pools and long shoals, over which the water is drawn off rapidly but not dangerously.

There are four mill-dams crossing the river diagonally on this section, and are dangerous obstructions.

COUNTIES IN VIRGINIA.

The counties of Tazewell and Russell are well adapted to the raising of cattle, hogs, and sheep, the principal wealth of the country. Mr. Stewart embraces in his estate about 60,000 acres, feeding and shipping several thousand head yearly. Very little of surplus grain raised. Wise and Scott Counties are paying more attention to cattle, hogs, and sheep, being easier to market than grain, and paying better. These counties are poor and rough, being rich in coal and iron, but undeveloped. Much of

the land is owned by speculators. The people of this part of Virginia are looking forward to an early completion of the Richmond and Southwestern Railroad (a proposed line from Richmond, Va., to Louisville, Ky.). The road is partially located, and a force at work in Kentucky. With the completion of this road, they expect to find a market for their hidden treasures, coal and iron, which abound in large areas, and some of the coal measures being of a superior quality.

I consulted with many farmers, lumbermen, merchants, and lawyers, and they generally agree in regard to the Clinch being a bold and rugged river. Several families moved from Russell County, via the Clinch and Tennessee rivers, to the West, and two grain-boats passed down as early as 1820, without accident, thus showing this part of the river to be successfully used in its unimproved condition. I think they were exceptional cases, being a matter of necessity rather than of choice. Tazewell trades with Saltville; Russell, Wise, and Scott with Abingdon, Bristol, and Rodgersville; these towns have railroad facilities for shipping. Walnut lumber is being hauled from this section of the Clinch, 20 and 30 miles, and shipped by rail. The hills and mountains are well wooded, black walnut, oak, beech, cedar, poplar, and pine abounding. In 1872 the legislature of Virginia granted a charter to the Clinch River Improvement Company, but gave no money. About $1,000 was spent between Osborn's Ford and the State line, and much good accomplished. Three different times the people banded together to blast out "the Falls" to let fish up, but little progress was made, the rock being full of flint.

COUNTIES IN TENNESSEE CONTIGUOUS TO THE CLINCH.

Hancock, Hawkins, Granger, Claiborne, Union, Anderson, and Roane. I find here, as in Virginia, more attention being paid to cattle, hogs, and sheep, paying better and easier to market. Many farmers haul their products from Granger, Claiborne, Hawkins, and Union, to Knoxville, Tenn., 30 and 40 miles, over a very mountainous country. One hundred and twenty-five loaded wagons have crossed the Clinch River at Haynes (many of them from Virginia) in one day, traveling 45 and 75 miles to Knoxville. In 1845 the State expended $10,000 in improving Clinch River from the state line to its mouth. The gravelly shoals were plowed up to be taken out by high-water, but their expectations were never realized, Many wing-dams were built, but soon afterwards were utilized by parties building fish-dams, thus rendering the shoals more dangerous than in their unimproved condition.

OBSTRUCTIONS CLASSIFIED.

Sharp, craggy projections from the bluffs, extending into the river. Ledges of rock extending across the river, and showing sharp points above low-water. Large detached rock from the bluffs. Shoals of gravel and small rock. Islands dividing the waterway into narrow channels. Tow-heads formed by old traps and snags. Leaning trees and hanging limbs. Fish-dams and traps. Mill-dams.

PLAN OF IMPROVEMENT.

Ledges, mill-dams, fish-traps generally occur where the river is broad, fall great, and current rapid, thus requiring a very high tide to lessen the danger. Large bowlders, detached rock, and ledges should be blasted; loose rock and fish-traps taken out. Mill-dams, the most dangerous obstructions, should be taken out or have wide, strong aprons built to them. All obstructions should be removed to low-water mark, and where the shoals are broad, fall great, and the interests sufficient to justify, wing-dams should be built to control the water. I met and consulted many boatmen, and few favor wing-dams on the upper river, but favor them after two days' run from Osborn's Ford, as the tide frequently leaves them when they tie up at nights.

REASONS FOR THE IMPROVEMENT.

There is but one interest to be considered between Nash's Ford and Osborn's Ford—that of lumber. From Osborn's Ford to Haynes', a distance of 120 miles, there are other interests that should receive attention—large steam saw-mills, located at Sneedsville, Hawkins County, Tenn., logs will be sawed into lumber and flat-boated down the river. Several merchants living along the river buy grain and ship by flat-boats down the river to Chattanooga; about 10,000,000 feet of lumber in logs will pass down this winter and spring; 15,000 bushels of wheat and corn from section 3. Messrs. Kichburg & Scales have opened rich mines of zinc ores, and taken out 100,000 tons, 60,000 of which they have shipped to their smelting-works at Clinton, Tenn. There are other rich deposits in Claiborne County undeveloped that would be worked if the facilities for shipping were improved, and it certainly would bring money to a poor but deserving people.

The boldness of the river bed in many places, and the scarcity of water much of the season, preclude forever any attempt to improve the river, except for flat-boats during "tides." I met Mr. William Ramey, living 10 miles below Osborn's Ford. Mr. Ramey has built and boated one hundred and fifteen barges of grain, meeting with but one accident. He complained very bitterly of mill-dams and fish-traps, regarding them as the most dangerous of obstructions, destroying every year more or less property. Mr. Cox, a merchant living at Craft's Mills, told me he has shipped grain by flat-boats for several years, and never had an accident. Farmers and others living along the river should be prohibited from cutting trees into the river. I would recommend that obstructions be removed and an occasional wing-dam built from Osborn's Ford to Haynes'. Boatmen generally acknowledge good results from work already done. All distances and quantities are mere approximations. Information was derived from farmers, merchants, and others living along the river. On section 3 we have four mill-dams: George Craft's, built about thirty-five years ago; Claiborne Neeley's, built about nine years ago; W. J. Livesay's, built in 1877; G. W. Harrison's, built in 1878. They are all grist and saw mills, on a small scale, and do a small business. They are located at the head of bad shoals, and are from 1 to 4 feet high, extending diagonally across the river. I would suggest the removal of parts of these dams or the building of strong and substantial aprons to them, which would lessen the danger but not remove it.

The nature and extent of the obstructions met with in the course of the examination will be understood by referring to the accompanying tables.*

COST OF IMPROVEMENT.

Estimated cost of improving Clinch River, from Nash's Ford to Haynes, a distance of about 161 miles:

Building wing-dams	$5,800
Removing ledges	5,230
Removing large bowlders	2,047
Removing small bowlders	4,030
Removing rocky points and cutting leaning trees	1,716
Removing mill-dams, fish-traps, and dams and snags	755
Contingencies, 25 per cent	4,902
	24,510

Very respectfully, your obedient servant,

E. C. Tollinger,
Assistant Engineer.

Maj. W. R. King,
Corps of Engineers, U. S. A.

X 6.

IMPROVEMENT OF DUCK RIVER, TENNESSEE.

Several efforts have been made by the State of Tennessee to secure steamboat navigation upon this river.

In January, 1840, an act was passed incorporating the Duck River Steam Navigation Company "to make Duck River navigable for steamboats, from Columbia to the Tennessee River," by means of locks and dams.

Again in January, 1844, another company was incorporated "to encourage the navigation of Duck River with steamboats, as high up as Columbia, or higher, if found practicable," and in January, 1846, "The Duck River Slackwater Navigation Company," was incorporated "to navigate Duck River with steamboats, barges, and keels, from Columbia to Tennessee River," by means of canals, locks, and dams.

Notwithstanding certain exclusive privileges granted these separate companies, they all have failed in securing the object sought. The last-named company did some little work below Columbia, partially com-

* Omitted. Printed in House Ex. Doc. No. 77, Forty-sixth Congress, third session.

pleting one or more locks, but, it is understood, the company is now perpetually enjoined from prosecuting work.

An examination of this stream was made in October, 1879, from Centreville to its mouth, a distance of 68 miles. Centreville is about 55 miles below Columbia, the point sought to be reached by the Navigation Company; and, based on this examination, the first appropriation of $7,000 was made by act of 1880.

The obstructions are rock reefs, gravel bars, snags, and sunken logs, and the improvement in progress consists of rock and gravel excavation, removing snags, overhanging trees, &c., and building wing-dams, so as to secure from 2½ to 3½ feet of water during a boating season of from four to six months, which will answer all practicable purposes for some years to come.

Active operations were carried on by hired labor for about three months, the daily average of force employed being ten men.

During the year the necessary boats were built and set at work, and fifty-five snags and 1,281 overhanging trees were removed between Five Island Shoals and Wilke's Shoals.

It is proposed to use the funds available, and the new appropriation of $10,000 asked for, in permanently deepening the navigable channel at the various shoals between Centreville and the mouth of the river, by excavating reefs, and by narrowing the channel by wing-dams, removing snags and the numerous trees lodged in the channel; which latter is one of the most troublesome, if not really formidable obstructions, to the navigation of this river. The navigation of this stream has been carried on by small steamboats from the Tennessee, which ascend during high-water.

Duck River is in the collection district of New Orleans.

The original estimate of cost of improving Duck River was		$35,118 00
Amount appropriated		10,000 00
Amount expended		2,799 18

Money statement.

July 1, 1880, amount available	$7,000 00	
Amount appropriated by act approved March 3, 1881	3,000 00	
		$10,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	2,598 03	
July 1, 1881, outstanding liabilities	201 15	
		2,799 18
July 1, 1881, amount available		7,200 82
Amount (estimated) required for completion of existing project		25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,000 00

X 7.

IMPROVEMENT OF OBEY'S RIVER, TENNESSEE.

This stream, like Caney Fork River, rises on the western slope of the Cumberland Mountains, and flows in a northwesterly and westerly direction to the Cumberland River, which it enters about 3 miles south of the Kentucky line.

In 1879 an examination of this stream was made, from the "Forks" to its mouth, a distance of 43 miles, upon which plans and estimates were made for its improvement.

The obstructions were found to consist, like those of most other streams in this region, of gravel bars, loose rock, rock reefs, snags, and overhanging trees, and the plan of improvement consists in removing these obstructions, and in building rip rap dams, to facilitate high-water navigation by steamboats from the Cumberland. These boats can usually ascend during four or five months in the year, only the smaller ones being engaged in this trade.

Work was begun in August, 1880, and was continued about four months, during which time, an average force of twenty-six men was employed, and the following quantities of work were completed:

45 cubic yards solid rock, excavated from channel.
1,782 cubic yards gravel, loose rock, &c., removed from channel.
966 cubic yards stone placed in dams.
1,758 logs, snags, overhanging trees, &c., removed from channel.
9 stone dams (fish-traps) removed.

The first appropriation, $4,000, for this stream was made in June, 1880, and although the name was spelled *Obed's* River, it was decided, that Congress intended the money to be applied to this stream, an examination and estimate having been ordered by Congress for *Obey's* River, and the report of this examination having been sent in just before the appropriation. *Obed's* River is a small tributary to Emory River, on the east side of Cumberland Mountains, and no examination has ever been made, with a view to its improvement.

It is very desirable that this spelling should be corrected, so that the accounting officers of the Treasury may not be left in doubt as to the intention of Congress.

The matter was referred to in my last annual report, and the Senate made the correction, but it was again omitted in the committee of conference.

This stream is tributary to the Cumberland River, therefore is in the collection district of New Orleans.

Original estimate of cost of improving Obey's River, Tennessee, was	$11,869 00
Amount appropriated	6,500 00
Amount expended	3,124 78

Money statement.

July 1, 1880, amount available	$4,000 00	
Amount appropriated by act approved March 3, 1881	2,500 00	
		$6,500 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,280 05	
July 1, 1881, outstanding liabilities	1,844 73	
		3,124 78
July 1, 1881, amount available		3,375 22
Amount (estimated) required for completion of existing project		5,369 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		5,369 00

X 8.

IMPROVEMENT OF CANEY FORK RIVER, TENNESSEE.

This stream rises on the western slope of the Cumberland Mountains, and runs in a northwesterly direction to the Cumberland River, which it enters near Carthage, Tenn.

Some work was done on this stream about 1830 and 1846 by the State of Tennessee, and in 1879 an examination was made under authority of Congress, from Sligo to its mouth, a distance of 72 miles.

The obstructions consist of gravel shoals, rock ledges, snags, and overhanging trees, and the plan of improvement is simply to remove the obstructions, and to build stone dams at certain points, to facilitate navigation at moderately high-water by boats drawing not more than 3 feet of water, the season of navigation being about five months—usually from February to June.

Work was begun in August last and continued until interrupted by high-water in December, and was resumed in April and was in progress at the end of the year; in all, about six months' work, with an average force of 28 men, under Assistant Engineer C. A. Turrill.

The following are the quantities of work done:

91 cubic yards solid rock excavated from channel.
2,368 cubic yards gravel, loose rock, &c., removed from channel.
555 cubic yards stone placed in dams.
3,956 logs, snags, overhanging trees, &c., removed from channel.
260 linear feet wing-dam built.

The navigation of this stream is chiefly carried on by boats from the Cumberland River that make trips up it when the stage of water and trade will permit.

The work is not sufficiently advanced to justify any deductions as to the amount of benefit that has been secured to commerce, but it is understood that those engaged in the navigation of the stream are satisfied with the results accomplished.

The application of the balance of the present appropriation, and that herein estimated for, will be needed for continuing operations as already indicated.

This stream, being tributary to the Cumberland River, is in the collection district of New Orleans, and Nashville the nearest port of delivery.

The estimate of cost of improving Caney Fork River, Tennessee, was	$30,228 00
Amount appropriated	10,000 00
Amount expended	4,867 75

Money statement.

July 1, 1880, amount available	$6,000 00	
Amount appropriated by act approved March 3, 1881	4,000 00	
		$10,000 00
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	3,867 51	
July 1, 1881, outstanding liabilities	1,000 24	
		4,867 75
July 1, 1881, amount available		5,132 25
Amount (estimated) required for completion of existing project		20,228 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		12,000 00

X 9.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

As early as 1823 the legislature of the State of Alabama passed "an act to improve the navigation of Coosa River, and to aid in its connection with the Tennessee waters," and in 1824 this act was formally approved by Congress.

In 1828 Congress provided that any surplus of the grant for improving Tennessee River, should be applied to the improvement of the navigation of the Coosa, Cahaba, and Black Warrior rivers.

It is not probable that much, if anything, was done under these acts, although steamboats have been plying on the Upper Coosa, for some thirty years.

In 1870 an examination of the Coosa, authorized by Congress, was made between Greensport and the Selma, Rome and Dalton Railroad Bridge, a distance of 77 miles, and in 1872 an instrumental survey was made of this same part of the river, upon which were based plans and estimates for its improvement.

In 1875 an examination was made of the river from Rome to Wills Creek, near Gadsden, a distance variously estimated at from 120 to 153 miles (with the presumption in favor of the shorter distance) and upon this examination was based a project and estimates for improving this part of the river, so as to give a navigable channel 80 feet wide and 4 feet deep at extreme low-water, involving more or less work at fifty-one different obstructions.

These surveys, it will be observed, leave a gap of 29 miles between Gadsden and Greensport unsurveyed.

An appropriation was made in 1876 for improving Coosa River, between Rome and the Selma, Rome, and Dalton Railroad Bridge, and under this appropriation and subsequent ones, work has been carried on continuously since that date.

From Rome to Greensport the Coosa River, although quite crooked, is an exceptionally favorable one for navigation, the bed and banks being generally of a permanent nature and the mean depth being great as compared with the average width.

The obstructions are generally of a kind to be readily and effectually overcome. They consist of gravel bars, rock reefs, and bowlders, the former being the most troublesome—as they are, in some cases, likely to recur—but the latter, when once removed, are permanently disposed of.

The project for this improvement contemplates the excavation of a channel, at least 3 feet deep at extreme low-water, through all these bars and reefs, the excavation being partly accomplished by building wing-dams and causing the current itself to scour the softer materials out, and partly by blasting the rocks and removing the *débris* by hand.

As stated in last report, this part of the river has been put in a tolerably good condition for navigation, some fourteen of the worst obstructions having been more or less removed, and it was thought best to suspend operations on it until the more important obstructions below Greensport are overcome.

The more serious of these obstructions—Ten Island Shoals—consists of ledges of rock crossing the river and causing it to widen out to two or three times its average width, and giving it a fall of 24 feet in a distance of 5 miles, nearly the whole of this fall being concentrated in less than 2 miles. This not only diminishes the depth greatly, but causes such a strong current that locks and dams are rendered necessary.

The present plan consists of three locks and three principal dams, one of the latter extending entirely across the river, 1,100 feet, and one across a chute to be used as a canal, while the third dam, some 2,000 feet long, is built longitudinally above the first lock to retain the water passing over Whistenant's Shoals, and form a navigable channel along the river bank.

During the past year the work has been directed to the building of

these locks and dams, and the following quantities have been completed:

	Cubic yards.
Masonry laid (cut stone)	921
Masonry laid (rubble)	3,298
Stone quarried	614
Stone cut for locks	748
Solid rock excavated from channel and lock-pits	1,945
Loose rock, earth, &c., excavated from quarries, lock-pits, &c	12,654
Solid rock placed in dams	189
Earth embankment	7,040
Earth placed in coffer-dams	847
Timber hewn for bulkhead, dams, &c.....feet B. M..	132,936

The condition of the improvement at the end of the fiscal year, June 30, 1881, was as follows:

1. The worst obstructions *above Greensport* had been either wholly or partially removed, so as to need no immediate attention, but they should be completed before or as soon as the Ten Island Shoals become navigable.

2. *At Ten Island Shoals, lock No.* 1 was completed ready for the gates, and the longitudinal dam was completed, excepting a short spur connecting with the lock.

Lock No. 2 was well under way; the foundation pit was excavated, and nine-tenths of the stone quarried and cut; about one-fourth of the masonry was laid.

The foundation of the dam, 1,100 feet long, extending across the river from this lock, was built, and two other dams, extending below the lock and connecting with Wood's Island, were well under way, when an unprecedented flood occurred, which greatly damaged them and made it necessary to do considerable of the work over again. It should be remarked, that the damage resulted from the dams being in an unfinished state, and that when properly completed they will withstand any flood that may occur.

Lock No. 3.—A quarry had been opened, and the quarrying and cutting of stone was well under way.

The necessary excavation of the channel was completed by blasting through the several reefs between the head of the shoals and lock No. 2.

The work has been continued through the entire year by an average daily force of 140 hired laborers.

Lieut. W. L. Marshall, United States Engineers, has had supervision of this work from its commencement, in 1877, until May 10, 1881, when he was relieved from duty in this district.

The work has been in local charge of Assistant Engineer S. H. Chittenden until January 25, 1881, and of Assistant Engineer M. T. Singleton since that date.

Owing to the peculiar surroundings of the work, the unhealthy climate, the scarcity of labor and materials, and the difficulty of finding suitable quarries, the work has been prosecuted at a great disadvantage, but, owing to the zeal and efficiency of the three gentlemen just mentioned, it has made creditable progress, both as to quality and quantity of work done.

The work below Greensport, when done, may be considered permanent, and will require but little expense for repairs. That above Greensport will probably require renewal in certain parts, especially the channel through gravel bars.

These locks and dams, with an additional dam across the river at

Broken Arrow Shoals, will extend navigation to the Saint Clair County coal fields, and give the steamboats, now navigating the river, 24 miles additional river trade.

Should it be decided to continue the work as far as the Selma, Rome and Dalton Railroad Bridge, the limit specified in the appropriation acts, the additional length of navigable river will be about 77 miles, and a lock will be needed at the Broken Arrow Dam.

In regard to the amount of commerce now on this river, Assistant Engineer Singleton reports:

Six steamboats are now employed on the river, including two tugs. All of these run about nine months, and three of them run all the year round. I am unable to state their tonnage.

The four freight and passenger steamers vary in size from 120 feet long by 20 feet beam, to 165 feet long by 33 feet beam, and drawing from 22 to 36 inches, laden.

During the year ending June 30, 1881, these boats carried 25,000 bales cotton, 4,000 tons pig iron, 3,000 tons guano, 500 tons coal, 3,000 tons supplies and merchandise, and the tugs delivered to saw-mills at Gadsden 20,000,000 feet of timber, and to other mills 5,000,000 feet. Of the lumber cut from this timber, about one-fourth was again handled by boats, or over 6,000,000 feet.

River men report a minimum depth of 3 feet between Rome and Greensport. There is probably less than this at extreme low stages.

They are all anxious to see the work now in progress completed. Writing on this subject, Messrs. R. B. Kyle & Co. say:

"The opening of the river to Broken Arrow will double the tonnage on the river and open up a coal trade that will put large numbers of boats and barges in the trade, and cause the development of immense beds of iron ore along the banks of the river, making an immense carrying trade."

This work is in the collection district of Mobile. The revenue collected at the nearest port of entry is unknown to me.

The original estimates of cost of improving the Coosa River are	$552,347 00
Amount appropriated	285,000 00
Amount expended	206,098 41

Money statement.

July 1, 1880, amount available	$97,850 10	
Amount appropriated by act approved March 3, 1881	60,000 00	
		$157,850 10
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	72,092 81	
July 1, 1881, outstanding liabilities	6,855 70	
		78,948 51
July 1, 1881, amount available		78,901 59
Amount (estimated) required for completion of existing project		267,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		175,000 00

X 10.

IMPROVEMENT OF OOSTENAULA AND COOSAWATTEE RIVERS, GEORGIA.

The Coosawattee and Connesauga, by their junction, near Resaca, in Northwestern Georgia, form the Oostenaula, which in turn unites with the Etowah at Rome and forms the Coosa.

As early as 1828, efforts were made to establish a line of water communication across from the Tennessee River, via Hiwassee, Ocoee, Connesauga, and Oostenaula rivers to the Coosa River, and thence to the Gulf of Mexico. In fact, this line was used for some time, with a portage of about 5 miles between the headwaters of the Ocoee and those of the Connesauga. An examination of this portage was made, by order of Congress, in 1828 by Lieut. Jefferson Vail, with a view to securing a water supply for a canal as a connecting link in this line of water communication.

Examinations of these streams were made, in accordance with acts of Congress, in 1872 and 1874, and in June, 1874, an appropriation of $10,000 was made for improving the Oostenaula.

The examination embraced the Coosawattee from Carter's Mill to its mouth, a distance of 45 miles, and thence down the Oostenaula to its mouth, a distance of 60 miles (both distances by estimation).

Work was in progress at the beginning of the fiscal year, and was continued about three and a half months, with an average daily force of 21 men.

The following are the quantities of work done:

3,042 cubic yards gravel, loose rock, &c., removed from channel.
111 cubic yards solid rock excavated from channel.
287 cubic yards stone placed in dams.
46 snags and overhanging trees removed from channel.
13 cords brush put in dams.
133 cubic yards stone quarried.

The work done during the year was mostly upon the Coosawattee, and is thought to include all that is needed by the commerce of that river.

The balance of the appropriation is now being applied to the Oostenaula, and should any further appropriation be made it can be expended to the best advantage on that stream.

There is but little commerce on either stream, and I am unable to ascertain that any steamboat ascended the Oostenaula during the year, although I am informed that it is proposed to build a small boat for that trade this season.

No further appropriation is recommended for the Coosawattee, and the small amount asked for will doubtless complete all that is necessary on the Oostenaula.

The cost of improving both streams is estimated at	$28,208 50
Amount appropriated	25,000 00
Amount expended	24,120 49

Money statement.

July 1, 1880, amount available	$2,777 28	
Amount appropriated by act approved March 3, 1881	1,000 00	
		$3,777 28
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	2,794 52	
July 1, 1881, outstanding liabilities	103 25	
		2,897 77
July 1, 1881, amount available		879 51
Amount (estimated) required for completion of existing project		3,208 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		3,208 00

X II.

IMPROVEMENT OF ETOWAH RIVER, GEORGIA.

As no change has taken place in the status of this stream since last annual report, but little can be said, excepting in repetition of what was then recommended, viz, that—

There being no prospect that the balance of the appropriation for this stream can be profitably expended upon it, I would respectfully recommend that Congress be asked to make that amount available for the improvement below Rome, Georgia, where the Etowah merges into the Coosa River.

The survey reported in December, 1879, shows that nothing whatever can be done to make the Etowah navigable without recourse to a system of locks and dams, at a cost of over $2,000,000, for 63 miles, or $31,746 per mile, with no prospect of corresponding advantages.

The appropriation should, therefore, be expended on the Coosa, where it will be of some advantage to navigation, or covered into the Treasury.

Total amount appropriated:

Act of August 14, 1876	$10,000 00
Amount expended	1,237 80
Amount available for use, as recommended, if approved by Congress	8,762 20

Money statement.

July 1, 1880, amount available	$8,762 20
July 1, 1881, amount available	8,762 20

X 12.

IMPROVEMENT OF OCMULGEE RIVER, GEORGIA.

As early as 1763 the Province of Georgia provided "for keeping clear the channels of her rivers and navigable creeks" by setting apart certain fines and forfeitures for that purpose.

In December, 1817, Georgia, having in view the internal improvement of "several copious and extensive rivers" in that State, passed "An act to appropriate money for the improvement of the internal navigation of the State of Georgia," allotting "the sum of $10,000 for the improvement of the Oakmulgee River." Again, in December, 1826, the State provided "for the improvement of the navigation in certain water-courses," appropriating for the Ocmulgee River, above Macon, $10,000; below Macon, $20,000. In 1836 and 1837 $10,000 in each year was appropriated by the State for improving this stream. All these appropriations were to be expended under the direction of commissioners. Undoubtedly this stream, and others provided for, were then the best, if not the only highways in that region, which accounts, in part, for the large amounts appropriated.

This river, by its junction with the Oconee, forms the Altamaha, and furnishes a natural outlet to the ocean for the lumber, cotton, and other products of Central and Southeastern Georgia.

By act of Congress, 1852, the "Ockmulgee, up to Macon," was ordered to be examined and surveyed. In 1875 an examinntion was made "from the city of Macon to the city of Covington"; and also an examination of the river from Macon to its mouth, and upon this latter examination was based the first appropriation ($10,000) for improving this river, by act of 1876.

The obstructions are principally snags, sunken rafts, sand and gravel bars, overhanging trees, and occasional reefs of rock. The channel is tortuous and shifting, and the caving in of the banks is largely productive of additional obstructions.

The current is quite rapid, and at many of the sharp bends shows the usual disposition to break over at high-water and eventually cut off the points by forming a new channel of shorter and steeper slope.

At such points rafts are often drawn in among the trees, where they become a total loss, as the cost of getting them out would exceed their value. The remedy for this is either to cut out the trees and roots and allow the river to cut a navigable channel across these places, or to put in cribs of timber or booms to prevent the rafts from leaving the main channel.

The work has been carried on by hired labor, with an average daily working force of ten men, by Assistant Engineer C. A. Locke, under the direction of Assistant Engineer B. W. Frobel, who has local charge of the Ocmulgee and Oconee rivers. During the year, 359 cubic yards of rock, clay, gravel, &c., and 540 snags and logs were taken from the channel, and 43 overhanging trees cut down. A steam derrick-boat has been constantly employed snagging, excavating, and straightening the channel. In addition, a large amount of work, scraping and plowing, was done at Hubbard's Shoals, of which a detailed survey was made, and the necessary test-pits dug and holes bored. A scraper was ironed and rigged upon the derrick-boat, for use in scraping gravel-bars at Hubbard's Shoals and Winslow Point. Assistant Engineer B. W. Frobel reports that on July 1—

There was 5.2 feet of water in the new channel (at Hubbard's Shoals), and this gives 3.2 feet upon the unusually low stage of 1879. I think that 5 feet (even at that stage) can be secured by scraping or plowing, and this would admit the passage of such boats as now ply upon the river at all seasons.

The commerce of the Ocmulgee consists largely of lumber, cotton, wool, fertilizers, &c. During the past year the Georgia Land and Lumber Company have rafted to the seaboard about 18,000,000 feet of lumber, and this year expect to raft 30,000,000 feet. Messrs. McDuffie and Merritt, of Hawkinsville, kindly inform me that there are now three steamboats running to that place:

The Mollie Fisher, 240 tons burden.
The Halcyon, 325 tons burden.
The Cumberland, 500+ tons burden.

It is reported that at least two other steamers, the Clyde, 200 tons burden, and the Ida (tonnage unknown) are engaged in the trade of the lower river.

This river is in the collection district of Brunswick, Ga., Darien being the nearest port of entry.

The amount of revenue is unknown to me. The nearest permanent light-house structures are probably the beacons on Wolf's Island, near Darien, Ga.

The original estimate of cost of improving Ocmulgee River, from Macon to its mouth, was		$56,240 00
Amount appropriated		49,000 00
Amount expended		43,442 11

Money statement.

July 1, 1880, amount available	$7,583 86	
Amount appropriated by act approved March 3, 1881	5,000 00	
		$12,583 86
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	6,416 75	
July 1, 1881, outstanding liabilities	609 22	
		7,025 97
July 1, 1881, amount available		5,557 89
Amount (estimated) required for completion of existing project		7,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.		7,240 00

X 13.

IMPROVEMENT OF OCONEE RIVER, GEORGIA.

The improvement of this stream was provided for by the State of Georgia, under various acts of her legislature.

In 1815 money was appropriated, and commissioners appointed to superintend its improvement.

In 1817, $10,000, and an additional $5,000 to be used above mouth of Fishing Creek, provided a certain "Oconee Navigation Company" relinquished their charter. In 1826 $20,000 was appropriated for river below Carter's Bridge. An examination of this stream was made in 1874, and upon it was based the first appropriation ($10,000) for this work by Congress.

The principal object of this improvement, at present, is to furnish an outlet for the commerce of Dublin and vicinity, a town isolated from railroads, and dependent entirely upon river and wagon transportation.

The obstructions are principally snags, logs, and sand-bars formed by sunken logs, and a few rock reefs that need reduction.

Active operations, in local charge of Assistant Engineer M. T. Singleton (under the direction of Assistant Engineer B. W. Frobel), with a steam derrick-boat, were carried on for about five months, with an average daily force of seven men.

Work was done both above and below Dublin, at Lapsey's Cut, Browning's Landing, Bird's Cut, Buzzard's Bar, and near mouth of Cypress Creek, and at Carr's Shoals; 236 logs, snags, and overhanging trees, and several boat loads of drift were removed. Timber was cut for a coffer-dam at Carr's Shoals, with a view to the excavation of the rock reefs forming this obstruction. It was expected that work would be completed during the past winter, but a rise in the river destroyed the coffer-dam and put an end to the work.

The river navigation is much improved by the clearing of the channel, but the improvement can only be rendered permanent by the use of a snag-boat, a part of each year, in removing the logs, drift, &c., that accumulate rapidly.

As stated in my last annual report, the estimates heretofore made were much too small for the work to be done.

The commerce of this river, below Dublin, finds its way to the ocean by the Altamaha, and consists of lumber, cotton, turpentine, corn, bacon, &c.

A steamboat, the Colville, 81 tons burden, is engaged in trade above Dublin, connecting with the Georgia Central Railroad. I have been unable to get information as to the vessels employed below that city.

This stream is in the collection district of Brunswick, Ga., Darien being the nearest port of entry.

The estimates made for this work were	$50,000 00
Amount appropriated	15,500 00
Amount expended	12,648 22

Money statement.

July 1, 1880, amount available	$1,879 19	
Amount appropriated by act approved March 3, 1881	2,500 00	
		$4,379 19
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	1,502 41	
July 1, 1881, outstanding liabilities	25 00	
		1,527 41
July 1, 1881, amount available		2,851 78
Amount (estimated) required for completion of existing project		34,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,000 00

X 14.

IMPROVEMENT OF RED RIVER, TENNESSEE.

An examination of this stream from Port Royal to its mouth, a distance of 38 miles, was made in December, 1880, from which it was found that—

An expenditure of about $10,000 upon the 38 miles of river examined in removing snags, overhanging trees, loose rock, and gravel, and in building a few stone dams, would enable the smaller boats from the Cumberland River to ascend this stream at medium stages of the water, and with sufficient frequency to carry off the heavier products of the neighboring country.

At its last session Congress appropriated $5,000 for this work, and it is proposed to utilize, as far as possible, the organized force employed on the lower Cumberland for this purpose as soon as it can be spared from its present work. Nothing was therefore done before the end of the fiscal year; but it is hoped that before the end of the present low-water season the work will be well under way.

There are three bridges across this stream, one for a railroad and the other two for turnpikes, the lowest being 41 and the highest 52 feet above low-water.

Unless these bridges are provided with draws the high-water navigation of this stream will be greatly crippled, as steamboats will be unable to pass under these bridges even with their chimneys lowered.

The river is now navigable for about four months in a year by a small boat drawing 15 inches of water. The principal article of commerce is tobacco, of which about 3,000 hogsheads are annually hauled to Clarksville.

The appropriation asked for, together with that already made, should be applied to the building of stone dams, removal of snags, overhanging trees, &c., as already indicated.

The nature of the improvement will be comparatively permanent, though a small annual expense for repairs and for the removal of future snags that may lodge in the channel is to be anticipated.

This stream is in the collection district of New Orleans. Nearest port of delivery is Paducah, Ky.

The estimate of cost of improving Red River, Tennessee, was	$10,103 00
Amount appropriated	5,000 00

No expenditures.

Money statement.

Amount appropriated by act approved March 3, 1881	$5,000 00
July 1, 1881, amount available	5,000 00
Amount (estimated) required for completion of existing project	5,103 00
Amount that can be profitably expended in fiscal year ending June 30, 1883.	5,103 00

X 15.

EXAMINATION OF HOLSTON RIVER, TENNESSEE AND VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., January 25, 1881.

GENERAL: I have the honor to state that the examination of "Holston River, in the counties of Sullivan, Hawkins, Grainger, and Hamblen, Tennessee, and Washington and Scott Counties, Virginia," has been

completed as far as practicable during the present season, and to submit the following report relative thereto:

Owing to an unusually early flood in this stream, followed by extreme cold weather, it was not practicable to extend the examination entirely through Granger County, and it is respectfully suggested that, should Congress decide to undertake the improvement of the Holston, the examination should be extended as far down as Knoxville, in Knox County, some 80 miles below the point where the present examination was interrupted by the freezing up of the river.

The examination was begun at Saltville, in Washington County, Virginia, on the *North Fork* of the Holston, which is the only part of the Holston that runs through Scott County, Virginia, and from which fact it was inferred that the North Fork was the one intended for examination, although the South Fork is nearly twice as large as the North Fork at Kingsport, where these streams unite. On the other hand, it is found that the North Fork has much more commerce and the country through which it runs is much less accessible to railroad communication. I have no doubt therefore that the North Fork is the one referred to by Congress, though it is equally probable that when the Holston proper is improved the needs of commerce will demand the improvement of at least 25 miles of the South Fork.

The examination was made by Assistant Engineer W. G. Sanborn, whose report herewith gives in detail all the obstructions met with, and estimates of the cost of improvement.

The number of obstructions is large, but they are generally of such a character as to be easily and permanently removed. The estimates appear to be liberal, and, from the nature of the case, the improvements may be so carried on as to benefit navigation before the whole work is completed, although the full advantage can only be realized when the improvement is extended to Knoxville, so that boats can take full advantage of the increased depth of water.

The entire length of river examined was 171¼ miles, and the entire cost of the improvement is estimated at $242,913, or about $1,418 per mile. To this should be added about $80,000, if the improvement is to be extended to Knoxville. This last sum is merely a rough estimate, based on the average cost per mile of the part of the river examined.

The improvement proposed is intended to give a channel 60 to 80 feet wide and 16 inches deep at extreme low-water, for steamboat navigation, as far up as Kingsport, or the mouth of North Fork, and to remove all obstructions down to low-water mark above that point, to facilitate the descent of rafts and flat-boats.

The entire area drained by the Holston, including South Fork, is about 3,680 square miles (of which 743,087 acres are improved lands, with a population of about 140,000), and, according to the census report of 1870, a true valuation of $33,395,247.

This river is in the collection district of New Orleans, the nearest port of delivery being Knoxville.

The Holston was examined from Kingsport to Knoxville by Col. S. H. Long, in 1830 (see report reprinted in H. R. Ex. Doc. No. 167, Forty-third Congress, second session).

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. W. G. SANBORN, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *January* 10, 1881.

MAJOR: I have the honor to report that, in accordance with your instructions, I made a reconnaissance of the North Fork of the Holston River, and that part of the main Holston from its junction with the North Fork to Noe's Branch; and as the two rivers are so very different in their main characteristics, also the nature and extent of the obstructions, and the character and objects of the improvements to be recommended, that I have thought it best to make separate reports upon each.

I.

I commenced the reconnaissance of the *North Fork of the Holston River* at the "old river salt works," just above the mouth of Salt Works branch, which is in the valley leading to Saltville, Washington County, Virginia, which town is about 1½ miles from the river; and I continued the reconnaissance uninterruptedly, in a small flat-boat, to its junction with the main Holston River at Rotherwood, Hawkins County, Tennessee, being, by my detailed estimate of distances, 91.4 miles.

The object of the reconnaissance was to obtain the data necessary to make an approximate estimate of the quantities and cost of improving the river to the extent that flat-boats and timber rafts might safely descend during the "tides," or rises that usually occur with considerable regularity during certain periods. From the best information that I could obtain in regard to the river, I believe the improvements here recommended, and upon which the estimates are based, would provide for a boating season, during tides, from December to June. During the remaining months boat-tides seldom occur, and in my judgment the cost of making improvements to the extent of providing sufficient depth of water on the shoals for these months, or during ordinary low-water, would be out of proportion to the benefits to be derived therefrom now or in the near future. The improvements here suggested would naturally form part of the system of any additional improvements that might become necessary.

The *North Fork* heads in the mountains some 35 miles northeastwardly from Saltville, and 10 miles above the two branches unite, and the river flows in a general southwesterly course in a narrow valley between the mountain ranges, occasionally receiving small tributaries that break through the River Mountain from the Clinch Mountain range beyond. None of these tributaries are navigable, but they afford an abundant water-power for the mills that are located upon them; they do not supply much water in the summer and fall months, but afford a fairly constant supply then, which is much increased during the winter and spring months, especially during times of heavy rains or melting snows, when they soon become mountain torrents.

The peculiar characteristics of the North Fork are uniformity of width, frequent and sudden changes of depth, constant succession of pools, separated by rocky shoals having a heavy fall and sharp changes of direction.

The North Fork is quite uniform in width, being from 200 to 250 feet wide in the upper part, and gradually widening to 300 to 350 feet wide, at the present water surface, at the lower part. It, however, occasionally spreads out so wide as to form shallow bars that will require the construction of dams to confine the water to such limits as will afford sufficient depths on the bars. There are but very few places where the river is washing away the banks, and there to so limited an extent that the effect may be safely disregarded. There are no cut-offs; indeed, the river may well be said to have a fixed regimen, and the engineer may safely calculate in advance the results that will follow any proposed construction.

The depth varies rapidly from a few inches on the shoals to 20 feet in some of the deepest pools, but generally the pools range from 3 to 10 feet in depth in low-water; yet in many of them it would not do to draw them down much by lowering the head of the shoal below, as there are bowlders and ledges in them that would thus become exposed.

The highest water ever known on the North Fork was in 1862, when it was above low-water as follows: Salt works, 14 feet; 42 miles below, 20 feet; 70 miles below, 25.8 feet; 77 miles, 23.0 feet; 81 miles, 22.0 feet; and 87 miles below, 25.0 feet. The next highest flood was in 1867, when at 42 miles below the salt works it was 18.3 feet; at 70 miles, 23.2 feet; at 77 miles, 20.5 feet; and at 81 miles below, 20.7 feet above low-water. In 1872 was the third highest flood, and was, at 42 miles below, 17.4 feet; at 70 miles, 21.7 feet; and at 77 miles below the salt works it was 19.4 feet above low-water. Since then the highest water was in 1878, when it was 13 feet above low-water at 42 miles below the salt works. The residents showed me bottoms at 12 and 16 miles below the salt works as high-water marks; but they were only 8 and 9 feet, respectively, above low-water, and, as there was no apparent reason why the flood line should be so low at either of these places, and as they could give no definite times

or places where the water-mark was, I do not think these places can refer to the floods, but rather to the ordinary high-water that has fallen under their observation.

Nearly all the shoals in the North Fork are caused by the sharp fall of its bed, and the remainder are caused by the widening of the river at that place. None are caused by the deposition of transmitted substances, except only so far as the ledges have arrested the onward movement of the gravel and pebbles; and in this case the substances are never deposited to the height of the ledge, and they would wash away on the removal of the ledge. It is a peculiar fact (and one that is easily understood from the facts previously stated) that nearly all the shoals retain comparatively the same fall during all ordinary stages of water. Only a few find relief from the water rising faster below than above them. There are no real gorges on the river.

For the first 6 miles from the river salt works the shoals are obstructed by water-worn bowlders of all sizes, which have been exposed in place by the water carrying away the surrounding material. The removal of these bowlders for a channel-way will leave the bottom comparatively smooth, and the fall sufficiently uniform; and nothing further is deemed necessary now except at Talbott Shoals, where some 250 cubic yards of stone dams will be required to confine the water to one channel.

At *Tumbling Creek Shoals* the main part of the river makes such sharp bends, and the channel is so obstructed, that boats never pass through it, but wait for water sufficient to allow them to take the small boat channel on the right of the island. This channel should be widened and deepened (mostly at the upper end), and most of the water turned through it.

One-fourth of a mile below, commences one of the wildest places on the river, and known as *Ball's Battery;* it has a fall of 19.3 feet in a distance of 1,800 feet; much of it being crowded into falls of 1 to 2 feet, over low ledges extending across with little lower places in them, making a very winding channel in ordinary water. There is no relief for the total fall, and its distance can be but slightly extended. The fall can be made comparatively uniform, by blasting a channel-way through the crests of the ledges and confining the water by low dams.

At *Kelley's Islands* the water simply needs to be confined to one channel, and the small bowlders removed.

The *Falls* are the most dangerous natural obstruction in the North Fork; they were formerly improved by private interests, by the construction of a wooden apron at the worst place; this answered pretty well until its partial destruction, when it became an obstruction itself, and caused the loss of several boats, and was then torn out.

The obstruction consists of ledges of hard rock, nearly parallel with the stream, that have a dip of about 45 degrees; they extend entirely across the stream for a length of 200 feet, then suddenly jump down 4 or 5 feet for a width of 40 feet; and the water pours over the *side* of this chasm, dashes against the opposite rock-bank, and then rushes for a short distance over the large bowlders and fragmentary ledges, and forms the pools below. The total fall can be lessened, and the vertical fall distributed, the chasm widened at its upper part, and the bowlders and fragmentary ledges removed, and the falls, the boatmen's terror, made perfectly safe with ordinary care.

The *Wild Waters Shoals* are rightly named, as the waters look very wild even in ordinary tides. They have a fall of 14.7 feet in 1,500 feet, and it is pretty uniform and only occasionally concentrated in small falls. The obstructions are very different from Ball's Battery, there being here only a few continuous ledges high enough to be dangerous; but the large bowlders and fragments of ledges are scattered everywhere. It only requires a wide channel-way to be cleared through these shoals; the fall cannot be much reduced, or materially modified.

Little Moccasin Creek Shoals are not dangerous, but are a serious obstruction because the water spreads out so thin on them. They simply require the channel to be cleared out, and the water turned fully into it and confined by dams.

The *Little Raven's Nest Shoals* are very long and very crooked, and have a fall of 25 feet in 7,100 feet. It will only be necessary to blast a channel-way through the crests of the high ledges, and remove the bowlders so as to make the whole depth of water there available, the fall now being comparatively uniform.

At *Jett's Shoals* the principal obstructions are ledges extending across, and two fish-trap dams. Open a channel-way through them is all that is necessary.

Hart's Shoals are scattered along in groups for several miles, forming quite serious obstructions. The upper shoals fall 15.7 feet in 3,400 feet, and the water spreads out very thin. It will be necessary to blast out a channel-way through the crests of the several obstructive ledges, and to clear the bowlders from the channel-way to make the whole depth of water available, and even then it may be necessary to construct dams to confine the water. The obstructions in the other parts of the shoals are large and small bowlders and ledges, which will only require the opening of a channel-way through them.

The *Larger Bent* or *Ford Creek Shoals* are short and sharp, having a fall of 10 feet in 1,300 feet, and in one place have a fall of 2½ feet in less than 100 feet; they are very wide and the water spreads all over them; they are the shallowest large shoals on

the North Fork, and there is no channel through them, the deepest water for a width of 20 feet was about 4 inches. It will be necessary to make a channel-way through by blasting off the crests of the ledges, and removing the bowlders, and confining the water to it by dams.

Freeman's Shoals have a fall of 7.6 feet in 800, over broken and continuous ledges, but will require only a channel-way blasted out, and the openings in the broken ledges closed up to force the most of the water through this channel, and this same construction applies to many other similar places.

Darter's Mill Dam is built on the *Broad Shoals*, which were then very bad, and are dangerous now, as the boats and rafts are very liable to be dashed on the rocks below, even if they get over the dam safely. A boat chute should be opened near the left shore in the dam, and the bowlders and high ledges below removed, and a dam built to prevent the water spreading over the shoals.

The obstructions at *Wilhelm's*, *Warm Spring*, and *Dickerson's Shoals* are very similar in character, being broken and continuous ledges and bowlders, and fish-trap dams, and they will only require the opening of a channel-way through them, and closing up the other openings in the broken ledges.

Jourden's Mill Dam and *Shoals* are but the fraction of a mile from the mouth of the North Fork; the dam is a substantial structure, and has a height of 4.2 feet above water surface below; it has a good boat chute on left side 60 feet wide that has 8 inches of water on it now, and it has a dam connecting with a small island that together confine the water for a length of some 250 feet; then it spreads out all over the shoal, so that a boat cannot get over the shoal after it has passed through the chute; in the first 300 feet the fall is 5.5 feet, and in the next 1,100 feet the fall is 12 feet. It will here be necessary to excavate a channel-way through the crests of the ledges near the left shore, and confine the water in it by a parallel dam connecting with the island; the river here is very wide, and the water must be confined by dams, and for permanency it would be advisable to build heavier and stronger dams than I have estimated on. The above-mentioned shoals are the most serious and dangerous natural obstructions in the North Fork, and until they are improved there will be but little relief for the navigation of this river. There are many other shoals and bowlders, trees and snags, that are now serious obstructions that should be improved or removed, but they have no special features that require particular description, and they are shown with sufficient fullness on the detailed estimate sheets.

In the improvements here suggested very little has been attempted in reducing the total fall at the shoals, or of distributing it through an increased distance, the general plan followed being to remove the dangerous bowlders, and to excavate the crests of the high ledges for a channel-way, distributing the abrupt falls sufficiently to destroy their dangerous character, and when necessary confine the water to these channels.

There are seven mill-dams that extend entirely across the North Fork that are now in use, and there are several old abandoned ones that are more or less destroyed. Of these seven in use Gilmore's is the first and is the lowest, and is used to direct the water to the channel on that side of the island that has his mill and main dam. It should be torn out entirely, as it diverts the water that is needed on the shoal below.

Bowman's Dam is a very poor, old, cheap structure across the main channel on the left of the island, and he has another dam close to his mill across the right-hand channel; the mill is an old shed of but little account and not much used. The left-hand dam is low, and it would cost but little to make a safe boat-chute through it.

Fleener's Mill and *Dam* are good structures, and the mill is much used; the dam is generally about 2½ feet above the water surface below, but it grows lower and lower toward the right shore, and there the water now runs over it from 2 to 12 inches deep. A good boat-chute should be made through it, far enough from the right-hand shore for the boats to avoid the rocks below.

Barker's is a small but much used mill at Kinderhook; the dam is roughly built, mostly of small bowlders, and has a fall of 2.7 feet to the water surface below, and in 300 feet the total fall is 3.7 feet. A boat chute should be cut through it, and an apron built from it.

Hilton's Mill is a good one and is much used; the dam is the most dangerous one on the river, and has caused the destruction of several boats, &c., and they have been raising it higher for several years without making any provision for the passage of boats, and it has become such a terror to boatmen that only the most daring attempt to "shoot it." It will be necessary to cut a chute for boats through it, and build an apron, and a dam to confine the water until the descent is made.

Darter's and *Jourden's Dams* have been referred to in connection with the shoals upon which they are built, the shoals being more serious obstructions than the dams, and it is not necessary to describe them here.

The detailed estimate provides for tearing out of so much of the old, abandoned dams as is necessary for a boat channel.

As to the propriety of permitting these dams to remain, I do not feel it necessary

for me to express an opinion, but I do feel it my duty to say that much less obstructive dams would give them the same power that they now actually obtain, if they would use modern water-wheels that utilize a reasonable part of the power developed.

There are many fish-trap dams in this river, especially in the lower part, but many of them have been abandoned, the owners complaining that the mill-dams prevent the food-fish from ascending the river. As these dams are built on the shoals and extend nearly or quite across the river, it will be necessary to remove such portions of them as obstruct the best channel, and I have provided for this in the detailed estimate sheet.

The cutting of the trees is generally to enable the boats to make the sharp bends so as to avoid being dashed against the bluffs or upon the bowlders close in shore.

The estimate for the removal of snags is designed to cover the cost of not only removing the actual snags, but the drift and such other obstructions as can be best removed by fire or chopping, &c.

There are now no bridges across the North Fork, the old Ross Bridge close to its mouth having been destroyed many years ago; they are, however, now building the masonry just below the mouth of Livingston's Creek, for the crossing of the Bristol Coal and Iron Narrow Gauge Railway; they are to have two spans of 109 feet each across the present water surface, and a land space of 80 feet; the center pier is to be built only 24 feet above the present bed of the river at that point, which would make the top less than 4 feet above the flood line of 1862.

The total fall of the river from the salt works to its mouth is about 820 feet, or an average of 9 feet per mile; of this there is an average fall at the shoals and dams of 7½ feet per mile; some 500 feet of the total fall was measured by a pocket level, and the rest has been estimated.

The total of the quantities estimated for the 91.4 miles are:

Loose rock excavation	cubic yards..	32,170
Solid rock excavation	cubic yards..	32,990
Stone dams required	cubic yards..	6,950
Trees to cut		386
Snags to remove		173

Total cost estimated $115,148, or an average cost of $1,260 per mile.

The estimate of quantities is believed to be ample to cover the improvements contemplated, but at the same time I believe it would be a wise policy to build the dams heavier and stronger to insure their permanency. The prices upon which the estimate is based are designed simply to cover the actual cost of doing the work continuously under favorable circumstances, with the proper equipment to do it most advantageously, and where the material excavated should be used in dams, a proper proportion of the whole cost is assigned to each part of the work. To provide for the increased cost for delays, &c., incident to all river work (but naturally less in this case than most rivers), and especially for the heavy increase from distributing the execution of it through several years, I believe it would be necessary to add some 25 per cent. to the above estimate.

If these improvements are decided upon, I would suggest that they be continued up the river 10 miles above Saltville to the junction of the two branches, in order to give an outlet to the valuable gypsum mines that are located there. This would involve an additional expense of some $12,000.

Although the improvement of this river to the extent here suggested would involve the outlay of a large sum of money, yet I feel it my duty to recommend it, not so much for the sake of developing new interests as to provide an outlet for those that have been once developed. For many years this river was the main outlet for all the country bordering upon it, and it was no uncommon thing to see 40 to 50 heavily-laden flat-boats leave the river salt works on a single tide, and many thousand barrels of salt were shipped annually from that place; also large quantities of gypsum of fine quality; also timber, grain, and other products of farm and forest; and at other places down the river, farms, mills, and iron-furnaces added their products. The dangers of navigating the North Fork and the Holston rivers were so great that on the opening of a branch railroad to Saltville the shipments of salt were diverted to it, and during the war most of the mills and furnaces were destroyed; since then, none of the furnaces, and but few of the mills have been rebuilt. The river has also been further obstructed by dams, and its difficulties and dangers increased, so that there is but small prospect of a return of the former prosperity until the river is so improved as to afford safe navigation for descending flat-boats. There are now five large salt manufactories between Saltville and the river; there are also extensive deposits of a fine quality of gypsum that are being worked here and at other points farther up the river. The opening of the river to safe navigation would give them a cheap outlet, and enable them to compete more successfully with the imported English salt; even now, some of the lower saw-mills ship their lumber to Knoxville, 160 to 180 miles by river, and then east through Bristol and Abington, cheaper than they can haul it over the hills and

mountains and ship it from those places. Quite a number of the farmers at different points told me they have had to give up raising bulky and heavy products because of the great cost of hauling them to market. There is an abundance of fine timber easily accessible to the river throughout its course. There are so many interests that would be benefited by improving the North Fork of the Holston River that I recommend that it be improved now to the extent provided for in the estimates for it.

II.

The reconnaissance of that part of the *Holston River* from the junction of the *North Fork of the Holston to the little run below Noe's Branch*, being for a distance of nearly 80 miles, according to my detailed estimate of distances. I could not continue at the time the examination of the river below this point, as I here found the ice had formed so thick in this long eddy as to prevent us breaking through it.

The numerous large tributaries that form the Holston River rise in the mountains from 100 miles in an easterly to 150 miles in a northeasterly direction, and, after uniting, flow in a general westerly course to the junction of the North Fork, which at the junction is but little more than half as large as the Holston. Together they constitute a beautiful river, which here changes its direction to a uniform general course to the southwest, and flows through a wide valley with extensive, fertile, and well-cultivated bottom-lands. The Holston receives numerous small streams from the north and south throughout the 80 miles examined, but none of them are navigable in ordinary water; and while they supply ample water for the mills upon their banks, yet during most of the year they do not furnish enough water to materially affect the Holston, and during the summer season they only contribute enough to supply the natural loss in the river.

The object of the reconnaissance was to ascertain the character, amount, and probable cost of the improvements necessary to open the river to such navigation as its importance and the interests to be benefited might require. After carefully considering the difficulties to be surmounted and the benefits to be derived, I have decided to recommend that the improvements be designed to open the river for light steamboat navigation, which would also provide for flat-boats and all ordinary timber rafts, and I believe that the estimates of both quantity and cost are ample to provide sufficient water on the shoals for this purpose during all ordinary stages of water; but no provision has been made in these estimates for any assistance to boats in ascending the shoals, other than to supply a sufficient depth of water.

The characteristics of the Holston are: it *diminishes* its width as it makes its descent; it varies its width rapidly, and changes its depth very suddenly; it has a fixed regimen; the changes of direction are seldom sharp; the pools are generally long and deep, and are separated by rocky shoals, which are the only serious obstructions to navigation, there being but few trees, snags, or drift that impede navigation.

The Holston River for miles below the junction of the North Fork has a width varying from 500 to 600 feet, and its general width decreases with its descent, so that the lower part of the 80 miles covered by this examination has a width of only 400 to 500 feet. In all parts of its course the Holston varies rapidly in width; in some cases contracting so much as to produce a considerable fall below it, yet not creating any obstruction. In many instances it is divided by islands into several channels, but in only one instance, viz, Poor Valley Shoals, does it reach a width of half a mile from the extreme left to the extreme right shore. At most of the shoals the river increases considerably in width, but that can hardly be said to be the cause of the shoals, except in a few instances, for generally the obstructions are continuous or broken ledges of rock, extending in most cases fully across the river.

Although the depth of water changes very suddenly in the Holston, yet it has generally sufficient depth of water in its channel at all seasons for light steamboat navigation, except upon the shoals, and here the water often maintains its depth close up to the ledges at the head of the shoals, and as suddenly regains upon the other side of the ledge, and in the rest of the shoal the bed rock is seldom less than 2 feet below the crests of the ledges. There are numerous flexures in this river, but they are seldom very sharp or very long, and it maintains its general course with much uniformity. It is nowhere seriously cutting into its banks, and there are no cut-off channels, and many of the islands remain substantially as they were fifty years ago. Some few have entirely disappeared, and in a few other instances the inside channel has filled up, so that they are islands now only in high-water. The main channel changes only at very few places, and on the whole the changes are so very slight that the river may well be said to have a fixed regimen. The engineer can therefore safely calculate the results to be obtained from any proposed improvements, and can rely on their continued usefulness for many years. Some thirty or forty years ago the State of Tennessee made some improvements at the worst shoals, and though they were of cheap construction they served their purpose well, and have been of great benefit to the navigation of the river, and even now some of them render important service, and need

only to be repaired and strengthened to constitute part of these proposed improvements. The pools are generally long, and have from 3 to 15 feet depth of water in them at its lowest stage; they are generally free from all kinds of obstructions to navigation, and most of the ledges that do extend into and across the pools have either a sufficient depth of water over them or a navigable channel through them; where they have neither, the estimates provide for blasting a channel through them.

Most of the shoals in the Holston are of the same general character and do not require to be severally described to understand the nature of the obstructions. These obstructions consist of high, or low, continuous, broken, or partial ledges of hard rock extending completely across the river, or overlapping each other so as to make it difficult or dangerous for boats or rafts to steer from one opening to another. In many cases the openings are so narrow as to be dangerous; in other cases the crests of the ledges are so nearly level, or there are so many small openings through them, that the water spreads over the whole shoals and becomes very shallow everywhere. The construction proposed is to open a connecting channel through the crests of the ledges, and confine to this channel so much of the water as may be necessary to afford the required depth of the shoals. There are a very few cases of shallow water on the bed-rock and small rock shoals, where it will be necessary to confine and dam back the water so as to give sufficient depth of water over them. At the head of many of the shoals there is one and sometimes several narrow ledges rising almost vertically to the height of several feet above the bed-rock, thus forming a dam that forces the water to rise over it, making a deep pool above and increasing the natural fall of the shoal below. This peculiar fact can be made very useful, if due care is used in blasting a channel of the proper width and depth through these ledges. Long and Poor Valley shoals are the two most serious obstructions to navigation in the river, and they are very similar in their leading characteristics; both are very long and shallow; both have a heavy but comparatively uniform descent over low continuous ledges of hard rock, and neither has any sudden jump-offs; both were once improved by the State; and at the Poor Valley Shoals the dams are yet serviceable and do much good; but at Long Shoals the dams have been nearly destroyed. At Poor Valley Shoals the total fall can be reduced and better distributed, and the estimates provide for repairing and strengthening the old dams, and for building new ones, &c., and by these means nearly all the water at ordinary stages can be made to pass through the improved channel, and it will be of sufficient depth at all times.

At Long Shoals the total fall cannot be reduced, but it can be made nearly uniform by a connecting channel through the crests and high ledges, and most of the water can be led to this channel and confined therein by stone dams. These constructions will make a very rapid current in the improved channel at both these shoals; and some provision for assisting ascending boats will in time be necessary, and, if the navigation should ever increase sufficiently to justify the expense, it would be advisable to put in locks at both these shoals. There are no serious obstructions to the free navigation of the Holston other than the shoals. The only bridge across the river in these 80 miles is the railroad bridge to Rogersville, and it is so high that it is no real obstruction. There is only one mill-dam, and, as it does not extend entirely across the river, it does not interfere much with the passage of boats up or down. There are numerous fish-trap dams, and the estimates provide for the removal of such parts as obstruct the best channel. The total fall of the Holston in the 80 miles examined is about 280 feet, or 3.5 per mile of average fall; over 200 feet of this was measured with a pocket level and the rest was estimated. Of the total fall some 230 feet is at the shoals and ripples. The highest flood ever known in this part of the Holston River was in 1867, when it was at the following heights above low-water: At 18 miles below the junction of the North Fork it was 31 feet; at 42 miles it was 41 feet; at 59 miles, at the pool below Poor Valley Shoals, it was 40.5 feet; at 67 miles it was 39.3 feet; and at 74 miles below the junction of the North Fork it was 38 feet above low-water. In such a flood the river spreads over the highest bottoms and presents a comparatively uniform flood line; in ordinary freshets, when the river remains within its banks, there is not such a uniformity, and in most cases the river dams back upon the foot of the shoals and give them considerable relief; it is, however, of comparatively short duration.

The estimates for this 80 miles provide for the excavation of 5,430 cubic yards of loose rock and gravel, and 20,060 cubic yards of solid rock, for building 21,650 cubic yards of stone dams, and for the removal of six snags, at a cost of $127,765, being at an average cost of $1,600 per mile.

The estimate of quantities is believed to approximately represent what will be actually found necessary to execute the improvements here contemplated. The estimate of cost is designed to cover not only the actual work here specified, but the cost of such auxiliary works as may be necessary to properly execute this work. Allowance has also been made for the usual increase of cost arising from delays and interruptions incident to a river of this character. The estimate is based on doing the work to the

best advantage with proper equipment, and working continuously during the whole of the working season.

There is a large area of country tributary to the Holston River, and much of it is well settled and well improved, and part of the products of the farms, mills, mines, and quarries of this large section even now find their way to market by river. If these improvements should be executed they would add greatly to the value of all the lands near the river, and would afford all the people cheap, easy, and reliable access to their best markets at all seasons of the year. So great has been the demand for steam navigation that several parties have already tried to run small steamboats here, and other parties, who now flat-boat it, say they will put on strong, light-draught steamboats if the river is so improved as to permit them to navigate it regularly in safety. The interests to be subserved by these improvements are so great and so extended as to affect large numbers of the people in the counties through which the river runs, and I forbear to attempt any enumeration of these interests here. I have heard the people at different points along this river state the advantages of the improvement of the river to their section, and I have duly considered the expense of overcoming the obstacles to the safe navigation of the Holston, and I am fully convinced that this river should be improved as soon as possible to the extent provided for in these estimates.

Respectfully submitted.

W. G. SANBORN,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

X 16.

EXAMINATION OF POWELL RIVER, VIRGINIA AND TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 17, 1881.

GENERAL: I have the honor to report that the examination of Powell River, in counties of Lee, in Virginia, and of Hancock and Claiborne, in Tennessee, has been completed in accordance with your instructions of July 28, 1880.

The nature of this stream is such that it can only be used for downstream navigation by rafts and flat-boats, and cannot be made navigable for steamboats, except at an enormous expense for locks, dams, &c. The present and near prospective needs of commerce seem to require only a small outlay for removing gravel bars, bowlders, and other obstructions above low-water, so as to facilitate the passage of boats and rafts on medium stages of the river. Assistant Engineer W. G. Sanborn, who made the examination, and whose report is appended hereto, estimates that this can be done for $35,580, which will probably be sufficient.

An examination of this river was made in 1875 by Mr. W. M. Gordon (see Report of the Chief of Engineers, 1876), whose estimate for improvements of a similar character to those herein recommended was $24,000.

The area drained by Powell River is 1,322 square miles, with a population of 42,407, and an estimated valuation of $7,445,136.

Powell River is in the collection district of New Orleans.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. W. G. SANBORN, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *February* 17, 1881.

MAJOR: I have the honor to submit the following preliminary report on the reconnaissance of Powell River from Shaver's Ford, in Lee County, Virginia, to its junction with the Clinch River:

It now requires a tide of 5 feet in the lower and 6½ feet in the upper part of Powell River to make a boating tide for the ordinary flat-boats now used. To improve this river so that flat-boats might safely run on a 3½ to 4 feet tide would require the following expenditures:

For the removal of 2,750 cubic yards of sand and gravel, at 60 cents	$1,650
For the removal of 6,250 cubic yards loose rock, at 80 cents	5,000
For the removal of 6,000 cubic yards solid rock, at $1.80	10,800
For the removal of snags, drift, and cutting trees	1,200
For building 4,000 cubic yards wing-dams, at $2.75	11,000
	29,650
Add 20 per cent. for engineering and contingencies	5,930
Total cost of improvement	35,580

Most of the excavation will be above low-water, easily accessible and easily disposed of without moving it far. I would most earnestly recommend the improvement of this river. It is the only outlet for the surplus products of the large and fertile country bordering upon it. The Clinch, Powell, and Cumberland mountains hem in this region and prevent outlet, save by this one natural channel. All the people here are deeply interested in this improvement, as they see in it the only relief they can have from the continual losses to which they are subjected. I found, upon careful investigation, that in twelve years over twenty boats have been wrecked, and their cargoes lost, to say nothing of those that have been more or less seriously injured. The value of these boats and cargoes amounts to more than the cost of the improvements here recommended. I found also that large losses have been occasioned in the upper part of the river by the tides being insufficient in the present condition of the river, to permit them to ship off their surplus products. There are so many dangerous places in the river that boatmen dare not run after dark; they have to tie up and wait for daylight, and sometimes the water falls so fast during the long winter nights that they lose the tide, and have to wait there until another occurs. Perhaps I cannot better illustrate the *tax* of navigating this river than by stating the fact that at Shaver's Ford wheat now sells at 40 cents less per bushel than at Chattanooga, while the freight, at shipper's risk, is only 15 cents per bushel, thus leaving 25 cents per bushel, or 33⅓ per cent. of its initial value, to cover the risks and profits of river navigation.

I found it would be difficult to get accurate and reliable information of the number of flat-boats that annually left the Powell River; I therefore procured from twenty-nine boat yards on the river the number of flat-boats that they had built for a certain period of years, and made an average of them for one year, and the sum of these averages gave one hundred and twenty-nine flat-boats as the average for one year for this period of years. As the commerce of this river is on the increase, this average for several years does not as well represent its present amount as the fact that in the reconnaissance I found thirty boats waiting to leave on the next tide (although the previous tide occurred only three weeks before), and others in process of construction. Zinc, lead, and iron are found in inexhaustible quantities at and near the river, and they now afford considerable commerce, and are rapidly developing into extensive interests. Coal is found abundantly, but is not now mined for shipment. The timber interest is very large and rapidly developing. During the examination I counted one hundred and eleven rafts of logs ready to leave on the next tide, and the workmen were busy hauling in more logs; some of these rafts contained 90 to 100 logs, but I suppose the average of all would not exceed 70 logs to the raft. I could not obtain reliable information of the number of rafts leaving Powell River during any definite period of time.

The *guesses* of parties of whom I inquired ranged from 200 to 1,000 rafts per annum. I suppose the average of these two would be reasonably close.

In 1844 the State of Tennessee spent some $7,000 for the improvement of Powell River within her limits, and has done nothing for it since. Within the last three years the Union County Zinc Company have spent some $2,000 improving the river below their mines. The people and boatmen have done all they could, and now they appeal to the United States to give them the aid necessary to make navigation safe and reliable, and I heartily indorse the improvement of this river.

Respectfully submitted.

W. G. SANBORN,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

X 17.

EXAMINATION FOR A CANAL TO CONNECT THE WATERS OF THE SAVANNAH RIVER WITH THOSE OF THE HIWASSEE AND TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., January 14, 1881.

GENERAL: I have the honor to state that the examination of "the headwaters of the Savannah River in connection with the headwaters of the Hiwassee and Tennessee rivers," with a view to ascertaining if the waters of the last-mentioned streams can be united with those of the Savannah by means of a canal, has been completed, and to submit the following report thereon.

Referring to the small map, herewith, it will be seen that the connection of the waters in question would, if practicable, form a link in a chain of water communication between the Ohio River and the Atlantic coast; which, on account of its directness and climatic advantages, would be one of the most important transportation routes in the United States. In fact it would combine in a remarkable degree the advantages of the Mississippi River, which is open throughout the year, and of the Erie Canal, which, in spite of its being frozen up five months in the year, forms an invaluable artery of commerce between the great agricultural and manufacturing areas.

There is but one serious engineering question in regard to the feasibility of this transportation route, viz, the question of lockage. Had the topography of the country been such that navigable water of the Tennessee could have been reached from the Savannah by simply digging a canal across the divide, and without locks or even with a small number of them, the connection would no doubt have been made years ago, and its commercial value would have been incalculable.

The existence of a summit, to be overcome by locks, detracts from the commercial value of the route in two ways, viz, it increases the cost of the improvement in the first instance, and secondly, it increases the time and cost of transit, which virtually lengthens the route, and thus tends to neutralize its advantages over other routes.

To ascertain exactly the extent of these disadvantages would require a detailed survey, which did not come within the scope of the present examination, but we can, in a general way, estimate some of the more important elements involved from data now available.

The route in question should be made navigable for the same class of boats that can navigate the Tennessee and Savannah rivers. The locks and canal trunk should, therefore, be of the same dimensions as those now building at Muscle Shoals on the Tennessee River, which will pass boats 300 feet long, 60 feet wide, and drawing 5 feet of water. Smaller boats could, of course, be provided for at considerably less cost, which might answer for local traffic; but the magnitude of the proposed work is such that, if undertaken at all, it should be done on a scale that would enable it to compete successfully with existing through routes.

Referring more particularly to the Hiwassee route, it is found that, from the navigable waters of the Hiwassee at Charleston, Tenn., to the summit at Hightower Gap, a difference of level of 1,300 feet must be overcome by lockage, and from the summit to Augusta, on the Savannah, 1,850 feet, the distance being 291 miles.

Headwaters of Hiwassee, Little Tennessee, and Savannah Rivers.

SCALE: 0 5 10 MILES.

See small square on adjoining map.

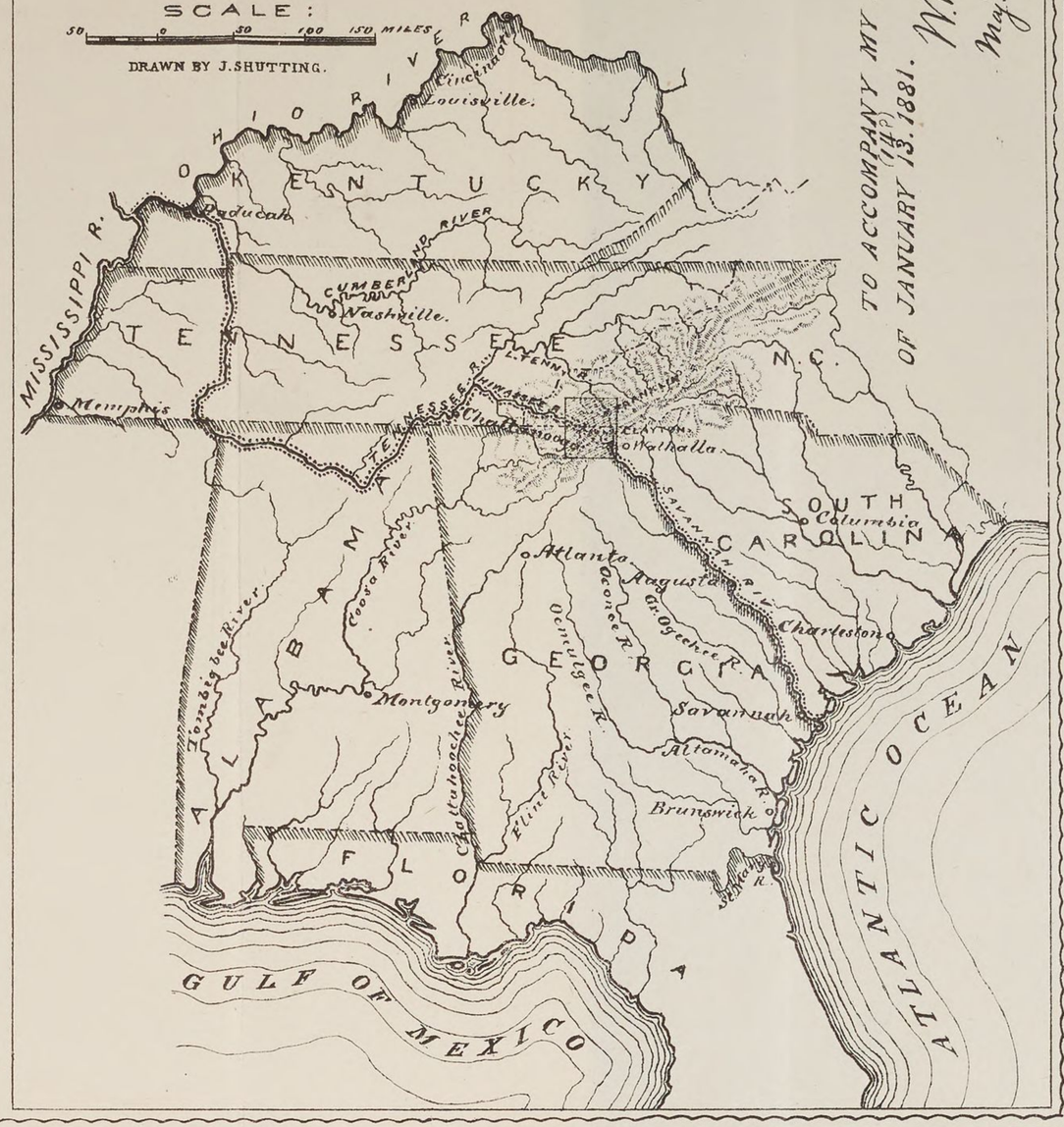


Proposed Water Route connecting Tennessee and Savannah Rivers.

SCALE: 50 0 50 100 150 MILES.

DRAWN BY J. SHUTTING.

TO ACCOMPANY MY REPORT OF JANUARY 13. 1881. W. P. King Maj. & Engrs.



The total lockage would therefore be 3,150 feet, and assuming that the ordinary form of canal-lock is to be used, and that the canal trunk and dams can be so located as to admit of locks of an average lift of 15 feet, it would require 210 locks, or about three times the number on the Erie Canal.

An important question naturally comes in at this point as to whether a considerable number of these locks cannot be replaced to advantage by inclined planes, similar to the outlet lock above Georgetown, D. C. If so, a very great reduction in cost can be effectedin that way. With this view Mr. Whinery was instructed to observe, as far as practicable, whether the topography of the country was favorable to this plan, and it appears from his examination that in the vicinity of the summit there are a number of places where the inclined plane could be used to advantage, and a more extended survey may show that it can be quite generally used. If so, the advantage to be expected will be apparent from the following rough estimate.

On the west side of Hightower Gap the fall is about 400 feet in 1 mile, which would require 27 locks at an average cost of, say, $150,000 each, or a total cost of $4,050,000. I believe the same lift can be overcome by an inclined place for $500,000, or about one-eighth the cost of the locks. In this estimate I have not undertaken to compare the relative costs of canal trunk, dams, &c., in the two cases, but have no doubt of the advantage being decidedly in favor of the inclined plane in these items, as well as in the economy of water, since it could, if necessary, be operated by steam, and there would then be no loss of water except from leakage and evaporation.

It will be seen, then, that the cost of the proposed improvement may by the use of inclined planes be greatly reduced from what the amount of lockage would seem to indicate, and there would also be a great saving in time of transit from the same cause.

As to the relative feasibility of the Little Tennessee and Hiwassee routes, it appears that the former has a considerable advantage in regard to a summit level without a tunnel, and to the amount of lockage; but the Hiwassee route is about 110 miles shorter, and strikes the Tennessee River below the mouth of the Clinch, which greatly increases its volume, and below the troublesome shoals between the mouth of the Hiwassee and that of the Little Tennessee.

In order to a full investigation of the merits of these routes the following information will be necessary:

1. The cost of improving the Hiwassee, Little Tennessee, and Savannah rivers up to the head of practicable slackwater navigation.

2. Exact profiles of the routes through Hightower and Rabun gaps, with cross-sections at suitable points, from which it can be determined to what extent the inclined-plane system can be utilized and estimates of the cost of building the necessary canal can be made.

3. A comparison of the cost, distances, lockage, &c., of the Hiwassee and Little Tennessee routes with each other, and with the corresponding elements of the route via Tennessee, Coosa, and Ocmulgee rivers surveyed in 1874. (See Appendix C C, page 658, Report of Chief of Engineers, 1875.)

By making use of certain railroad surveys that have been made over a part of the route, the necessary survey ought not to cost more than $15,000, and could easily be made during one summer.

I would therefore respectfully suggest an appropriation of that amount, if Congress decides to take further action in regard to this route.

A detailed account of Mr. Whinery's examination will be found in his report herewith.

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. SAMUEL WHINERY, ASSISTANT ENGINEER.

WHEELER'S STATION, ALA., *December* 9, 1880.

MAJOR: I have the honor to submit the following report of an examination made in compliance with your instructions, of "the headwaters of the Savannah River, in connection with the headwaters of the Hiwassee and Tennessee rivers, with a view of ascertaining if a summit level can be secured of the waters of these respective streams, so as to unite them by a canal; that is to say, to ascertain if the waters of the Hiwassee and Tennessee rivers can be united with the waters of the Savannah River by means of a canal." (River and harbor act approved June 14, 1880.)

The examination was begun on the 1st day of November, 1880, and about ten days were occupied in the work; it extended from the junction of the Telula and Chattooga rivers, up the former and Dick's Creek to Hightower Gap, and thence down Hightower Creek to the Hiwassee River in one direction, and from same point up the Chattooga and Sticoa Creek, to Rabun Gap, and thence down the Little Tennessee River to Franklin, N. C.

Pocket instruments only were used; the elevations were determined by aneroid barometers, three of which were used, and the elevations computed from the mean of the three readings, corrected for the temperature of the air and for the variations of the standard barometer at the Signal Service office at Atlanta.

Wherever possible the elevations thus obtained were checked by readings at points on the various railroad surveys in the vicinity, whose elevations above the sea were known. When the observations were reduced it was found that, notwithstanding the unfavorable weather that prevailed during nearly the whole of the time, the results were very satisfactory.

The headwaters of the Hiwassee and Tennessee are separated from those of the Savannah by the Blue Ridge Mountains, and the contemplated canal must be carried over that range. The average elevation, above the sea, of its summit, is about 3,000 feet, but there are depressions, or gaps, where the summit is much below that height. Through one of these depressions the canal must pass if built, and the feasibility of the whole project will depend largely upon the question whether it is practicable to construct and operate a canal over these summits. My examination was therefore mainly confined to these passes and the descent from them on either side.

The lowest gap between the headwaters of the Hiwassee and the Savannah rivers is Hightower Gap, situated about 6½ miles south of the Georgia and North Carolina line, and about 14 miles west of Clayton, Rabun County, Georgia. The summit of this gap is about 2,650 feet above the sea; its western slope is drained by Hightower Creek, which flows into the Hiawassee about 6 miles from the gap. Its junction with the Hiawassee has an elevation of about 1,900 feet above the sea, making the descent from the summit of the gap 750 feet; 400 feet of this descent occurs within the first mile from the summit, and the balance is pretty evenly distributed over the remainder of the distance.

The eastern slope of the gap is drained by Dick's Creek, a tributary of the Telula River, which it reaches in about 7 miles, flowing in a southeasterly direction; the elevation of its mouth is about 1,780 feet above sea level, a descent of 870 feet from the summit, about 400 feet of which occurs within 1½ miles of the summit.

Both Hightower Creek and Dick's Creek are small streams, and the question of a sufficient water supply for the summit level of a canal through this gap must be considered at the outset.

I assume that the canal contemplated should have locks not less than 20 feet by 120 feet, with lifts of about 12 feet each, and that provision should be made for a maximum passage of at least 100 boats per day.

According to the latest and best authorities on the subject,* the amount of water necessary to operate the summit level of a canal is given by the formula

$$C = c \times \frac{1\frac{1}{2}\, e\, n}{L}$$

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* See "Constructions des Canaux et des Chemins-de fer," Paris, 1861; Report on the Marne-Rhine Canal, by Inspector-General Graeff; also discussion of the above report

in which

C = total cubic feet of water consumed, per running foot of the summit level per 24 hours.

c = cubic feet of water required to supply losses by filtration, evaporation, losses at locks, &c., = 6.

e = cubic prism of lift.

n = the maximum number of boats passing daily = 100.

Assuming that the summit level is 6 miles long, we find that the total amount of water required will be about 4,500,000 cubic feet for each 24 hours. This would require the constant discharge of a stream with a cross-section of 20 square feet, with a mean velocity of 3 feet per second.

Owing to the recent rains I could not ascertain accurately the minimum flow of the stream examined by me, but I am satisfied that both Dick's Creek and Hightower Creek combined will not furnish that amount of water until long after their beds drop below any practicable summit level for a canal through the gap under consideration. By fixing the summit level of the canal at an elevation of 2,000 feet above sea level, which would necessitate the construction of a tunnel about 5 miles long, it is probable that the supply of these streams at that elevation, supplemented by storage-reservoirs, would furnish an adequate supply of water to work the canal. Suitable locations for such reservoirs can, I think, be found in the valleys of the tributaries of Hightower Creek.

From the western portal of this tunnel the canal would follow down the valley of Hightower Creek to the Hiawassee River, a distance of 3½ miles. The lockage in this distance would be about 100 feet, and the topography is very favorable for the construction of a canal.

I am not aware that any surveys or examinations of Hiwassee River, with the view of making it navigable, have been made between the mouth of Hightower Creek and Savannah Ford; an examination, however, was made in 1874 from Savannah Ford to the mouth of the river, and estimates submitted for its improvement, by securing a channel of 2 feet in depth at low-water. (See Report of Chief of Engineers for 1875, Part I, pages 809 to 813.)

But the fact that it flows through a mountainous region, and that the fall from the mouth of Hightower Creek to the mouth of Hiwassee is at least 1,200 feet, or about 12 feet to the mile, would indicate that such improvement would involve great engineering difficulties and heavy expense.

From the eastern portal of the tunnel the canal would descend Dick's Creek to its junction with Telula, or, as it is called at this point, Terroree River, and thence down that stream to the navigable waters of the Savannah. Dick's Creek is a rapidly descending stream, with a narrow and tortuous valley, hemmed in by precipitous hills, and the construction of a canal along it would be very difficult and expensive. The descent from the eastern portal of the tunnel to Telula River is about 320 feet, and the lockage would be pretty evenly distributed over the whole distance of about 3¼ miles. Telula River, at the junction of Dick's Creek, is a stream about 65 feet wide and 1½ feet deep, and from this point on the method of improvement by slackwater navigation might be adopted. The rate of descent to the head of Telula Falls, a distance of 20 miles, is about 15 feet per mile, and no very serious obstacle would be met with in this distance, though the work would be expensive. At Telula Falls the river cuts through a spur of Telula or Chattahoochee Ridge. The stream rushes through a narrow cañon with perpendicular walls from 100 to 500 feet high. There are a number of almost perpendicular falls from 25 to 90 feet, and between these the stream is a rushing torrent.

From the head of the falls to the junction of the Chattooga, a distance of 4 miles, the descent is about 680 feet. This part of the river would present very great engineering difficulties, and could only be made navigable at enormous expense.

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by Col. W. E. Merrill and Assistant Engineer Thomas S. Sedgwick, in reports on the survey for the extension of the Chesapeake and Ohio Canal in Report of Chief of Engineers for the year 1876, part 2, page 58, *et seq.*

I have adopted Colonel Sedgwick's factors, except for the value of *c*, which I have diminished to 6, for the following reasons:

1. While the loss by filtration, &c., is much greater during the first few months after the canal is filled, the number of boats, *n*, is likely to pass through the canal during that time, will, for obvious reasons, be far below, and probably only a small fraction of, the maximum allowed, and consequently the surplus of water allowed for lockage will more than supply the greater loss by filtration.

2. At Hightower Gap the greater part of the summit level will be in the summit tunnel, where the losses represented by *c* will be almost nothing. There would be no tunnel at Rabun Gap, but the summit level would be at least two miles shorter than that assumed at Hightower Gap, and the amount of water required there will not be greater than at Hightower.

The elevation above the sea of the junction of the Telula and Chattooga rivers, as determined from the readings of the aneroid barometers, is 780 feet. This elevation is probably not far from correct. The elevation of the river at the crossing of the Atlanta and Charlotte Air Line Railroad, 10 miles below the junction, as furnished me by Ira Sage, esq., chief engineer of the road, is 709 feet, and the fall of the river between the two points is given by Mr. Carson, in the report referred to below, as 105 feet, which would make the elevation of the junction of the rivers 814 feet.

The Savannah River, below the junction of the Telula and the Chattooga, was examined in the autum of 1878, by Mr. J. P. Carson, civil engineer, under instruction of General Gilmore, of the Engineer Corps, and his report will be found on page 750, Part I, of the Annual Report of the Chief of Engineers for 1879.

A canal connecting the headwaters of the Savannah and the Little Tennessee must pass through Rabun Gap, one of the most remarkable depressions in the Blue Ridge. It is situated 2¼ miles directly north of Clayton, Ga. The elevation of its summit above sea level, as determined by the surveys for the Old Blue Ridge Railroad, and confirmed by later surveys, is 2,044 feet. The turnpike from Clayton to Franklin, N. C., passes through it, and to the traveler passing along this road, it has the appearance of a narrow valley separating two parallel ridges, rather than a gap in a great dividing ridge.

Considerable streams flow into it from the mountains on either side, and so low is the summit that some of these could without difficulty be made to flow at will into either the Tennessee or the Savannah River. No tunnel would be required to construct a canal through this gap, and the depth of the summit cut need not be greater than the saving of lockage would justify.

Within a short distance northward a number of considerable streams converge to form Little Tennessee River, and at the mouth of Mill Creek, 2½ miles from the summit, the surface of the stream is only 35 feet below the summit. At this point the volume of the stream was, when I examined it, fully 12,000,000 cubic feet per 24 hours. I made numerous inquiries of citizens in the vicinity, and their statements agreed that the stream never shrank to less than two-thirds of its volume at that time.

Adopting the same requirements for the water-supply of the proposed canal as at Hightower Gap, I think there can be no doubt that an abundance of water to supply the summit level can be had at this point.

Descending northward, the canal would follow the valley of the Little Tennessee to Franklin, N. C. The topography of this valley and the character of the stream is well suited to the construction of such a work. The fall of the stream is very regular and but little over 5 feet per mile. The method of slackwater navigation might be adopted with advantage. At Franklin the river is 150 feet wide. The fluctuation due to freshets does not much exceed 10 feet in height.

My examination did not extend below this point.

An examination of the river from Franklin to the mouth of Citico Creek was made by Mr. Maurice Kingsley, under direction of Major McFarland, in the year 1875, a report of which will be found in the Report of the Chief of Engineers for 1876, Part I, page 716. Mr. Kingsley had examined that part of the river from Citico Creek to its mouth in the previous season, a report of which will be found in the Report of the Chief of Engineers, as above referred to.

The descent south of Rabun Gap would be via Clayton, down Chechero or Sticoa Creek to the Chattooga, and thence to the confluence of the Chattooga and Telula. The distance from Rabun Gap to the mouth of Chattooga is about 24 miles, and the difference in elevation of the two points is about 1,260 feet. The character of the Sticoa and Chattooga is not very different from the Telula, except that the descent is more evenly distributed, there being no obstructions, such as Telula Falls, on the Chattooga.

As to the relative merits of the two routes examined there can be no doubt that, on the score of practicability and economy of construction and operation, the advantage is largely with the Rabun Gap route.

No summit tunnel nor feed-reservoirs are necessary on that route, and there is no question of an ample supply of water.

The summit level at Hightower Gap has about the same elevation above the sea as that at Rabun Gap, and the amount of lockage would be practically the same on each route, but at Hightower Gap a tunnel 5 miles long and extensive storage reservoirs must be constructed, and the supply of water is not as ample and reliable as at Rabun Gap.

These remarks apply only to that part of each route examined by me, and I venture no opinion as to the relative merits and economy of construction over other portions of either route. On the other hand, the advantage of directness and saving of distance is largely in favor of the Hiwassee route.

The distance from Chattanooga to Augusta via Tennessee River, Little Tennessee River, Rabun Gap, and Savannah River is in round-numbers 460 mlies, while the distance between the same points via the Tennessee River, Hiwassee River, Hightower

Gap, and Savannah River is only 350 miles, a difference in favor of the latter route of 110 miles.

It is proper, however, to call attention to the fact that the distance from Augusta to the navigable waters of the Tennessee River, to Citico Creek, on Little Tennessee, and to Charleston, on the Hiwassee, is almost the same, about 290 miles.

While from a purely engineering point of view it is entirely practicable to connect the headwaters of the Tennessee River with those of the Savannah by a canal, it may not be so from an economic or commercial point of view. I am not certain that the language of the appropriation act providing for this examination authorizes the discussion of this branch of the subject, and I venture to do so very briefly.

I believe that the summit level of the propose canal by either of the routes considered would be at a greater elevation above the sea than any one heretofore operated, or indeed seriously contemplated.

The summit level of the Chesapeake and Ohio Canal, as located a few years since is 1,972 feet; that of the James River and Kanawha Canal, as finally located in 1868, is 1,700 feet above sea level. The excessive lockage on these proposed canals has been, and is, a very serious argument against the propriety of building them.

The Erie Canal has 654 feet of lockage between Lake Erie and Troy. The Genesee Valley Canal overcomes a summit of 1,489 feet above tide-water, and the Morris and Essex Canal overcomes a summit of 1,557 feet above the sea.

The amount of lockage that must be used on the routes that we are considering to overcome the summit elevation of 2,000 feet, is, in round numbers, between Charleston, Tenn., and Hightower Gap, 1,300 feet; between the mouth of Citico Creek and Rabun Gap, 1,100 feet, and between the summit at either gap and Augusta, 1,850 feet. In this estimate is included both the canal and slackwater lockage on the routes.

I have not been able to obtain any reliable data as to the cost of lockage per ton of freight for each vertical foot raised or lowered on American canals.

It is usual to approximate this cost by estimating each lock as adding some assumed amount to the actual length of the canal. This assumed increase of length has been variously estimated at from ½ to 1½ miles for each lock of, say, 12 feet lift. From the information at hand I think it would be reasonable to assume that each 12 feet of lockage on these canals would be equivalent to adding one mile to the length of the canal.

On this basis the equated length of these canals would be:

	Miles
Distance from Citico Creek to Rabun Gap	109
Add 1 mile for each 12 feet of lockage	92
Equated distance, Citico to Rabun Gap	201
Rabun Gap to Augusta	180
Add for 1,850 feet of lockage	154
Equated distance from Rabun Gap to Augusta	334
Total equated distance from Citico Creek to Augusta	535
Add distance from Chattanooga to Citico Creek	166
Equated distance from Chattanooga to Augusta	701

HIWASSEE ROUTE.

	Miles.
Distance from Charleston, Tenn., to Hightower Gap	106
Add for 1,300 feet of lockage	108
Equated distance, Charleston to Hightower Gap	214
Distance from Hightower Gap to Augusta	185
Add for 1,850 feet of lockage	154
Equated distance from Hightower Gap to Augusta	339
Total equated distance from Charleston to Augusta	553
Add distance from Chattanooga to Charleston	55
Total equated distance from Chattanooga to Augusta	608

It will thus be seen that the excessive lockage on these lines practically increases the distance from Chattanooga to Augusta via Rabun Gap 54 per cent., and via Hightower Gap 75 per cent., or in other words, the cost of operating either of these canals will be 54 per cent. in the one case and 75 per cent. in the other greater than if there was an unobstructed level canal between the two points.

No estimate that would be better than mere guesswork of the cost of constructing these improvements can be arrived at without, at least, a preliminary instrumental survey of the whole of each route, but from the nature of the region traversed it is certain that they would be enormously expensive.

If it is thought that the requirements of commerce render the construction of a canal necessary over one of these routes, a complete and careful survey should be made of both, in order to determine accurately the comparative cost and relative merits of each.

I may add that materials for the construction of such works, such as timber and stone, of first-rate quality, are abundant over the whole of either route.

Very respectfully, your obedient servant,

S. WHINERY,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

X 18.

EXAMINATION OF RED RIVER, FROM PORT ROYAL, MONTGOMERY COUNTY, TENNESSEE, TO ITS MOUTH.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., January 13, 1881.

GENERAL: I have the honor to report that the examination of "Red River, Tennessee, from Port Royal to its mouth," has been completed, and to submit the report of Assistant Engineer C. A. Turrill, who made the examination.

It is believed that an expenditure of about $10,000 upon the 38 miles of river examined, in removing snags, overhanging trees, loose rock, and gravel, and in building a few stone dams, would enable the smaller boats from the Cumberland River to ascend this stream at medium stages of the water, and with sufficient frequency to carry off the heavier products of the neighboring country.

Before the *higher* stages of the water can be utilized in navigating this stream, it will be necessary that the bridges crossing it shall be provided with draws; and for low-water navigation, the amount of work necessary would be out of all proportion to the benefits derived, especially as all parts of the stream below Port Royal are within two or three miles of a railroad.

This river is in the collection district of New Orleans, and the nearest port of delivery, by water, is Paducah, Ky.

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. C. A. TURRILL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Nashville, Tenn., December 10, 1880.

MAJOR: I have the honor to submit the following report of the "examination of Red River, Tennessee, from Port Royal to its mouth," at Clarksville, Tenn., which was made in obedience to your instructions.

Red River is the principal tributary of the Cumberland River below Nashville. The length of river examined was estimated at 38.17 miles.

The compass and hand-level were used in obtaining the meanderings of the river and the approximate fall at the different islands and shoals passed, and soundings were obtained throughout sufficient to show the character of the stream.

I submit the following table of approximate results:

Localities.	Distance from Port Royal.	Length of shoal.	Least depth in channel at low-water.	Fall of each shoal.	Character of obstruction.	Improvement suggested.	Approximate quantities.
	Miles.	*Feet.*	*Feet.*	*Feet.*			*Cu. yds.*
Port Royal							
Port Royal Island	0.10	850	1.4	1.5	Overhanging trees and one gravel reef	Dredging	75
Crotzer's Island	0.59	1,800	0.9	2.5	Snags and trees; one gravel reef	Riprap dam	400
						Dredging	100
Can Shoal	1.60	600	1.6	0.6	No important obstructions		
Northington's Ripple	3.00	150	1.5	0.3	Overhanging trees		
Northington's Island	3.84	1,950	0.8	2.5	Two gravel reefs; trees in chute	Riprap dam	300
						Dredging	200
Lockhart's Island	8.33	4,850	0.8	3.2	Three gravel reefs; trees	Riprap dam	400
						Dredging	300
Murphy's Island	10.43	4,200	0.9	2.9	Three gravel reefs; trees	Riprap dam	400
						Dredging	125
Hancock's Island	12.23	3,200	1.0	1.6	Trees and loose rock; two gravel reefs	Riprap dam	300
						Dredging	200
Ford's Island	14.77	3,000	0.7	1.7	Snags and two gravel reefs	Riprap dam	400
						Dredging	150
Cave Spring Ford	16.00	100	1.7	0.1	No obstruction		
Killebrew's Island	16.04	1,200	1.0	1.0	Logs and trees; two gravel reefs	Dredging	150
Gardner's Island	17.00	1,940	1.3	2.6	Trees and two gravel reefs	do	150
Herring's Fish Trap	19.95	50	1.5	0.2	Loose rock	do	5
Bradbury's Island	21.27	950	1.5	1.0	One gravel reef	do	50
Trigg's Island	22.28	4,200	0.7	4.0	Four gravel reefs	Riprap dam	500
						Dredging	400
Trigg's Ford	23.57	100	1.5	1.0	No obstruction		
Metcalf's Island	26.60	1,200	1.5	0.8	Two gravel reefs	Dredging	60
Small's Island	28.30	900	1.6	0.6	No obstruction		
Warfield's Island	30.07	500	0.8	0.8	One gravel reef	Dredging	75
Duck Island	31.32	600	1.4	0.7	One gravel reef	do	50
Gill's Ford	33.30	50	0.7	0.1	No obstruction		
Clarksville Turnpike bridge	35.50				Height above low-water mark: 41 feet	Boats would have to lower their chimneys to pass under these bridges.	
Louisville and Memphis Railroad bridge	36.16				Height above low-water mark: 52 feet		
Hopkinsville Turnpike bridge	38.00				Height above low-water mark: 48 feet		
Mouth Red River	38.18						

Between the islands and shoals above mentioned are pools ranging in depth from 8 feet to 12 feet at low-water. The banks are about 30 feet above low-water mark, and the average width of the river is 125 feet.

There are 2 turnpike and 1 railroad bridges. Two of the three have a central pier, but neither has a draw. Their heights above low-water mark are given in the table of results.

A small steamer has been in the habit of making trips between Clarksville and Port Royal, principally for the purpose of bringing out tobacco. This boat draws 15 inches, light. The river is navigable for this steamer about 4 months in the year.

The improvement suggested would probably not materially lengthen the boating season, but would enable small steamers to descend with safety and load to their full capacity.

The country drained by Red River is in a high state of cultivation. The principal products are corn, wheat, and tobacco. About 3,000 hogsheads of tobacco are annually hauled to Clarksville from the farms bordering the river, an average haul of 15 miles.

The portion of the river from Port Royal to Clarksville lies entirely in Montgomery County, Tennessee, although if an uninterrupted season of navigation was assured as far up as Port Royal, the character of the obstructions above are so unimportant that the same kind of navigation could be secured with but little expense as far up as Keysburg, Ky., 25 miles above Port Royal.

The highest flood-mark obtained was found to be 33.5 feet above low-water mark, at which height the bottom lands are flooded.

I received valuable assistance and information during the survey from Capt. F. P. Gracey, M. H. Clark, and others, of Clarksville and vicinity.

Below I give an estimate of approximate quantities of work to be done, condensed from the table of results already given, in which is included an estimate of the entire amount of overhanging timber to be cut, which is by no means the least of the obstructions found, although a private subscription of $500 was expended in 1878 by citizens along the river in clearing some of the island chutes of trees.

Statement of cost of work.

Character of work.	Approximate quantities.	Estimated cost.
Riprap dam	2,700 cubic yards, at $2	$5,400 00
Dredging	2,185 cubic yards gravel, at $1	2,185 00
Overhanging timber	About 2,000 trees	1,000 00
Snags and loose rock	About 200 snags	600 00
Contingencies, 10 per cent		918 50
	Total	10,103 50

Very respectfully, your obedient servant,

C. A. TURRILL,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

X 19.

EXAMINATION OF THE SOUTH FORK OF THE CUMBERLAND RIVER, KENTUCKY.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 7, 1881.

GENERAL: In compliance with your instruction of the 28th of July, 1880, an examination has been made of the South Fork of the Cumberland River, Kentucky, and the report thereon is respectfully submitted.

The obstructions in the South Fork are reefs, bowlders, &c., similar in character to those on most of the other mountain streams in this vicinity, and there appears to be no difficulty in the way of a permanent improvement of this stream from its mouth to the Devil's Jumps, a distance of about 43.6 miles, at a cost of about $35,265.

From the Devil's Jumps to Kentucky line the fall is so great that it would probably be very difficult navigation even if improved. The estimated cost of improving these 8.7 miles is $27,538.

I would respectfully recommend that, if Congress decides to begin this improvement, the lower part of the river be first undertaken, so that the work will be useful as it progresses.

A detailed statement of the distances, fall, nature of obstructions, and the cost of their removal, will be found in Assistant Engineer Crozer's report, hereto appended. Mr. Crozer is an old resident of the Cumberland Valley, and has been employed on the Smith's Shoals improvement for the past two years, and he is therefore acquainted with the necessities of the locality and the cost of doing work there of the kind required for this improvement.

This river is in the collection district of New Orleans, the nearest port of delivery being Nashville.

Respectfully submitted.

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. W. C. CROZER, ASSISTANT ENGINEER.

SMITH'S SHOALS, KENTUCKY, *February* 3, 1881.

MAJOR: I respectfully submit the following report of an examination of the South Fork of Cumberland River made by me under your instructions.

The examination was begun on the 15th of November, but was suspended several times on account of ice and extreme high-water, and was only completed on the 29th of January. I began the examination at Cincinnati Southern Railway Bridge over New River, that being the most accessible point to the head of the South Fork, which is 8 miles below, at the confluence of New River and Clear Fork.

The cold weather set in on the 16th of November, the day after our arrival, and on the 22d the river froze over in the pools. The ice, together with the extreme low-water, rendered the passage of our boats so slow and tedious that at the mouth of Greasy Creek, 6 miles below the bridge, I left the river and had the boats hauled to Helenwood and shipped by rail to Pine Knot, and from there hauled to the mouth of Bear Creek, 5 miles below the Kentucky and Tennessee State line. We were delayed there one week by the flood of December 1. After having finished the examination from Bear Creek to the mouth of South Fork, at Point Burnside, I disbanded the corps on the 16th of December.

On the 18th of January I again went to New River to complete the examination from Greasy Creek to Bear Creek, but was prevented by a sudden rise in the river. While waiting for the water to subside I went up to the mouth of Buffalo Creek, about 15 miles above the bridge, and came down in a skiff. The river from Buffalo Creek down is a beautiful river, averaging about 175 feet in width, and with a very gentle fall for a mountain stream. It runs through wide fertile bottoms, the best portion of Scott County, Tennessee. With the exception of three mill-dams, and some few shoals and bars, it is a good river up as far as the mouth of Smoky Creek, some 40 miles above the bridge. There is an abundance of fine walnut, ash, poplar, and white oak timber along this stream and its tributaries.

While the river is not called the South Fork above the mouth of Clear Fork, it is in fact the main stream, being much larger than Clear Fork, and is about as wide above the bridge as the South Fork proper is for 20 miles below the State line.

One mile below the railway bridge the river changes suddenly from a wide, smooth stream with but few obstructions and gentle fall, to a narrow, rapid one, obstructed with large sandstone bowlders, containing from 50 to 500 cubic yards each. Descending, the fall becomes more rapid, the obstructions increase in size and frequency until, at a point 1 mile below the mouth of Clear Fork, and nine miles below the bridge, the fall is 28 feet in 1,400 feet. Here the massive sandstone bowlders range in size from 400 to 8,000 cubic yards each. The hills encroach on the valley until, 3 miles below the bridge, the bottoms disappear entirely; and from there to the "Devil's Jumps," 8¾ miles below the Kentucky and Tennessee line, the river (with a width of from 75

to 125 feet) runs into a wild cañon, the foot of the steep hills coming to the water's edge, while their tops, grandly escarped with massive sandstone, rise to a height of from 500 to 700 feet. The total fall from the bridge to the "Devil's Jumps" (a distance of about 52 miles) is 372 feet.

Below the "Devil's Jumps" the character of the river again changes, the fall becoming more gentle, the pools between the shoals longer, and width of river increasing to from 150 to 200 feet, the shoals shorter and less obstructed, and the tillable bottom lands again appear and continue to "Dick's Jumps" (a distance of 12½ miles). Total fall in this distance, 58 feet. The principal obstructions in this portion of the river are sandstone bowlders.

At "Dick's Jumps" another change occurs, the fall becoming less rapid, there being only 76 feet fall from here to the mouth, a distance of 31 miles; with the exception of a few bad places this is a beautiful stretch of river, varying from 200 to 400 feet in width.

From the mouth of "Little South Fork" up to the headwaters the river (and all of its tributaries) runs through the coal measures. There are numerous exposures of coal of splendid quality, from 2 to 5 feet in thickness, along the banks of the river, awaiting only its improvement to be mined and shipped to market. The value of coal alone that probably will be shipped the first year after the improvement of the river will be double the amount required to improve it. There is also an abundance of fine walnut, ash, poplar, pine (both white and black), and white oak along the river and its tributaries.

Just below the State line there is an old oil well that some fifty years ago yielded a fine quality of heavy lubricating oil; there being no outlet for it the well was allowed to fill up and the flow has ceased. There is now a company engaged in reopening it. This is supposed to be one of the finest oil territories in the United States.

I suppose there is not a stream of this magnitude in any State in the Union, and of the importance that this will be when improved, the improvement of which has been so long neglected.

I append a tabulated statement, showing in detail the obstructions and the improvements suggested,* which are for navigation only during floods 3 feet and over above low-water. The floods range from 20 to 60 feet above low-water.

The prices, 75 cents per cubic yard for solid rock excavation and $1.50 per cubic yard for riprap dam, may appear too small to you, but the greater portion of the solid rock is sandstone bowlders, which will require but little if any handling after being blasted, the water around them generally being deep enough to cover the *débris*. I have built dams here at Smith's Shoals during the last two years that have cost less than $1.50 per cubic yard.

ESTIMATED COST FROM STATE LINE TO DEVIL'S JUMPS.

31,000 cubic yards solid rock, at 75 cents	$23,250 00
1,350 cubic yards loose rock, at 50 cents	675 00
740 cubic yards riprap dam, at $1.50 cents	1,110 00
Contingencies, 10 per cent	2,503 50
Total	27,538 50

ESTIMATED COST FROM DEVIL'S JUMPS TO MOUTH OF SOUTH FORK OF CUMBERLAND RIVER.

27,395 cubic yards solid rock, at 75 cents	$20,546 25
11,895 cubic yards loose rock, at 50 cents	5,947 50
2,700 cubic yards gravel, at 30 cents	810 00
3,170 cubic yards riprap dam, at $1.50	4,755 00
Contingencies, 10 per cent	3,205 87
	35,264 62
Total estimated cost of improvement from State line to mouth of South Fork of Cumberland River	62,803 12

Very respectfully,

W. C. CROZER,
Assistant Engineer.

MAJ. W. R. KING,
Corps of Engineers, U. S. A.

* Omitted. Printed in House Ex. Doc. No. 91, Forty-sixth Congress, third session.

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Bd.: [342.] 1881/82, Doc. 4 = Congress 47, Sess. 1

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Am.b. 3040-342,4
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